OS2U: Shot from Battleships

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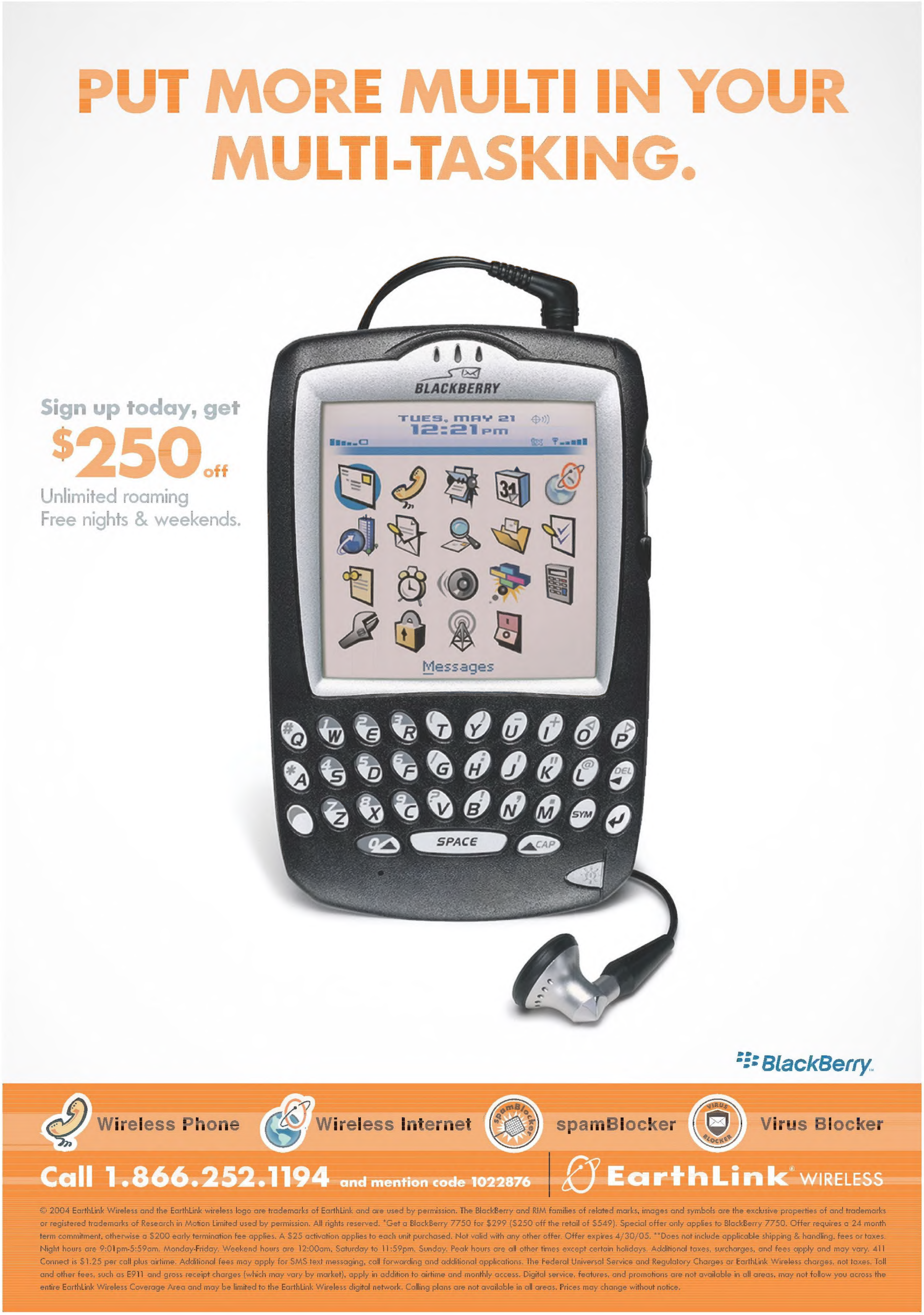
FIRST LOOK

WHAT'S NEW? THE U-2

COSMOLOGY: ARE WE HEADED FOR THE BIG RIP?
PAGE 48

MARCH 2005

All too often, investors take an extremely short-term approach to long-term retirement planning. But at Edward Jones, we believe the best way to prepare for retirement is to do just the opposite: follow investment strategies that have proven themselves over time. And to make sure we get to know you and your unique retirement needs better, our Investment Representatives actually encourage meeting with you face-to-face. Admittedly, it's not the trendiest investment



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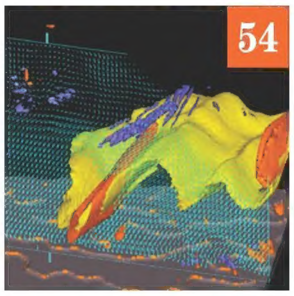
FEBRUARY/MARCH 2005 VOL. 19 NO. 6

AIR&SPACE Smithsonian

FEATURES



Cover: *Photographer Chad Slattery created a shadowy scene, with U-2 pilot Jeff Oleson approaching the waiting spyplane along that famously long wing.*

DEPARTMENTS

To generate donations for scholarships that send needy kids to college, Bill Jones relies on his ability to motivate others. To raise thousands of dollars for his church, he calls on his talent at being persuasive. And to get dozens of people to help him organize community programs, he taps into his management skills. With all he does, it's hard to believe Bill Jones is actually retired. Sure, he could have taken a break and relaxed. But Bill Jones learned something even more valuable in the U.S. Marine Corps. He learned that giving back is better than sitting back.

UNSELFISHNESS

– WILLIAM JONES
U.S. MARINE CORPS 1981-2003

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By the Book

If a visitor to the National Air and Space Museum wanted to read every label in all 21 galleries (assuming 200 labeled objects per gallery and 15 seconds to read each label), it would take 17 and a half hours. Clearly, anyone interested in the nation's collection of aviation and space artifacts needs another way to learn more about it.

What I am leading up to, of course, is our curators' books. Most people know that curators take care of the artifacts, but their primary task is original research into the history and technology of the artifacts. They then share the research with our audience. When we publish books, we fulfill the mandate of the Smithsonian Institution, which is the increase and diffusion of knowledge. Our books inform people currently in the field, as well as educate future scientists, historians, pilots, and astronauts.

Many of our most recent titles focus on the new Steven F. Udvar-Hazy Center: *Building America's Hangar: The Design and Construction of the Steven F. Udvar-Hazy Center*, by Lin Ezell, provides a behind-the-scenes look; *America's Hangar* was written by our curators and edited by military aviation curator Dik Daso; and *The Nation's Hangar: The Aircraft Collection of the Steven F. Udvar-Hazy Center*, by F. Robert van der Linden, spotlights our conservation and restoration program.

Books in other fields include *Earth from Space*, by Andrew Johnston, which presents stunning satellite photography; the reference work *Frontiers of Space Exploration*, by Roger Launius, which provides a wealth of historical information; and staff photographer Carolyn Russo's award-winning *Artifacts of Flight*, which presents images of some of our most famous objects (see "The Dept. of Etc.," Oct./Nov. 2004). *The Enola Gay*, by former Ramsey Fellow Norman Polmar, tells the story of the entire B-29 program.

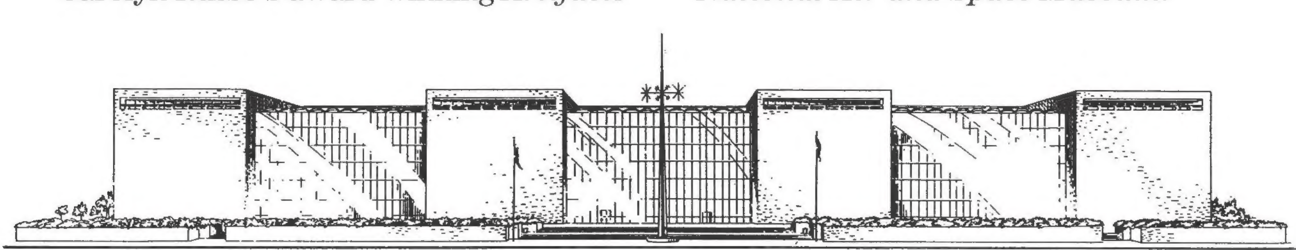
The 100th anniversary of powered flight prompted over a dozen titles by our staff, including *Wings: A History of Aviation from Kites to the Space Age*, by Tom D. Crouch; *The Wright Brothers and the Invention of the Aerial Age*, by Peter Jakab and Tom Crouch; *First Flight: The Wright Brothers and the Invention of the Airplane*, by Tom Crouch; *Great Aviators and Epic Flights*, by Von Hardesty; *Flight: A Celebration of 100 Years in Art and Literature*, edited by Roger Launius; *The Airplane in American Culture*, edited by Dom Pisano; *The Airplane: A History of Its Technology*, by John D. Anderson Jr.; and *Apollo 11: Artifacts from the First Lunar Landing*, by Robert Craddock.

In the last five years our staff has produced books published by 35 publishers. Until recently, our curators edited the Smithsonian History of Aviation and Spaceflight, a scholarly book series published by the Smithsonian Institution Press. The Smithsonian Museum Shops sell most of our books and regularly host book signings by the authors.

In the last three years, we have published about 11 books each year. Keep checking back with us to learn more and to be entertained.

All of our books can be found at *www.nasm.si.edu/museum/pubs/*

—J.R. Dailey is the director of the National Air and Space Museum.



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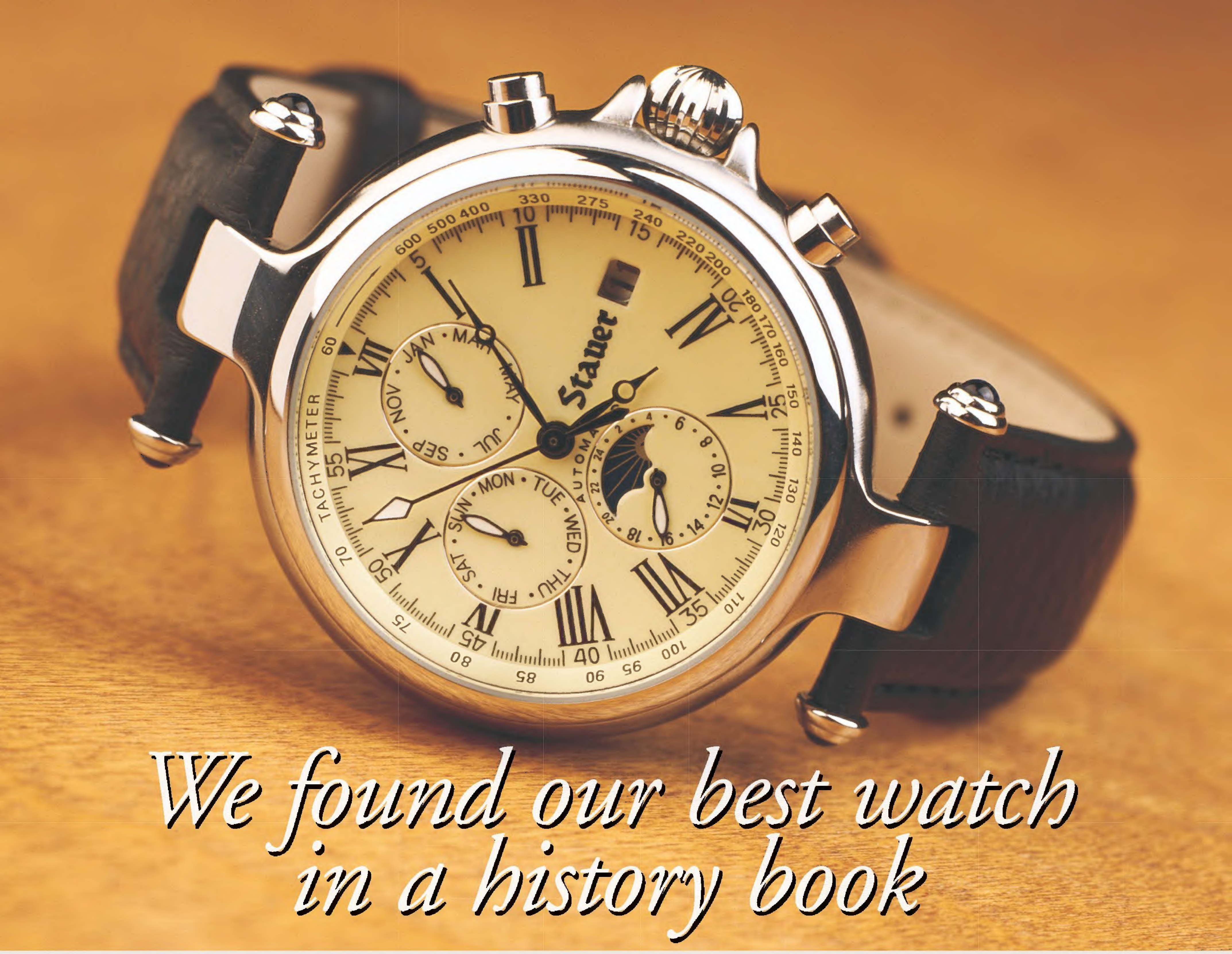

In 1922, a small watchmaker in Switzerland designed the first automatic watch to display the day, month and date. Only 7 of these magnificent time-pieces were ever made and this watch was almost lost to history. Today, they are so rare that our watch historians are willing to bid $300,000 for an original in mint condition.

These watches were among the most stylish of the roaring 20's. The Stauer watch design that you see here has the antique color, the vintage style and the innovative functions of the original that we have seen in a Swiss museum. Even the Breguet™ style hands are designed from the original. The owner of this legendary multi-functional watch is sure to look distinguished and set apart from the crowd. This Stauer watch is a limited edition, allowing you to wear a watch far more exclusive than many luxury brands.

The watch has a 24-jewel mechanical movement, the kind desired by fine antique watch collectors. We have updated this movement with an automatic rotor thus the watch never needs to be manually wound. The watch comes in a beautiful crocodile embossed case with a free second band.

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LETTERS

Remembering the Twins

As a long-time World War I fan, I've collected a number of books on Anthony Fokker, including Henri Hegener's *Fokker—The Man and the Aircraft* (Harleyford Publications, 1961). That book reports that the twin-boom Cessna C-336 Skymaster is an unintended copy of two twin-boom designs that weren't included in "Fork-Tailed Devils and Flying Shoes" (Dec. 2004/Jan. 2005). One is the Fokker M-9, a 1915 biplane comprising twin M-7 fuselages and tails with a pilot's pod in the middle and two 80-horsepower LeRhone engines in push-pull configuration. The second is the low-wing, liquid-cooled Fokker D-XXIII fighter prototype. Production was aborted by the German invasion of Holland.

A.N. Amith
Eldridge, Missouri

Your article states that in 1945, the de Havilland D.H. 100 Vampire "became the first fighter to exceed 500 mph." The Messerschmitt Me 262 flew 541 mph at 29,965 feet, and the Me 163 rocket fighter once achieved a speed of 623 mph.

Eugene Whitt
via e-mail

Your piece reminded me of a then-secret project I participated in involving the twin-boom North American OV-10 Bronco. In the early 1970s, I worked at Varo Inc. as a member of the team developing Pave Nail. Designed for the Bronco, the Pave Nail system was one of the first nighttime airborne target detection, tracking, and designation systems to guide Paveway laser-designated bombs. With the system, the OV-10 backseat observer could see targets at night while the aircraft was virtually invisible from the ground. Pave Nail employed an image-intensified telescope and a bore-sighted laser. The system was stabilized so the observer could maintain target track throughout a wide range of maneuvers. Throughout the development phase, the twin-boom Cessna 337 Skymaster served as our flying test bed.

In Vietnam, the OV-10 operated with buddy fighter-bombers carrying the Paveway bombs. Once the observer located the target, he would call for support and designate the target with the laser spot to ensure accurate impact.

Ken Sewell
Dallas, Texas

Realists Wanted

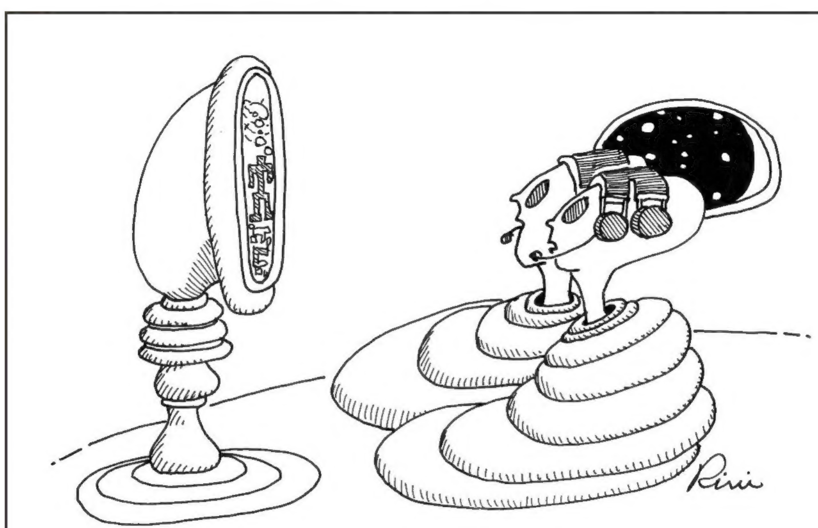
I found the Commentary "Explorers Wanted" and "Scenes From a Dry Planet" (both in Oct./Nov. 2004) much too optimistic about further exploration of Mars and, to a lesser extent, the moon. It seems fairly obvious that neither world offers an abundance of the elements critical to human survival. Until we learn fast and efficient ways to produce what we need from the substances on Mars and the moon, future expeditions can't come close to paying for themselves.

G. Kent Roberts
Abilene, Texas

Saved From the Mentor

I flew two missions in the T-34 that crashed from wing stress ("Save the Mentor!" Dec. 2004/Jan. 2005). I was going to fly another mission, but I am glad I didn't. It could have been me in that plane.

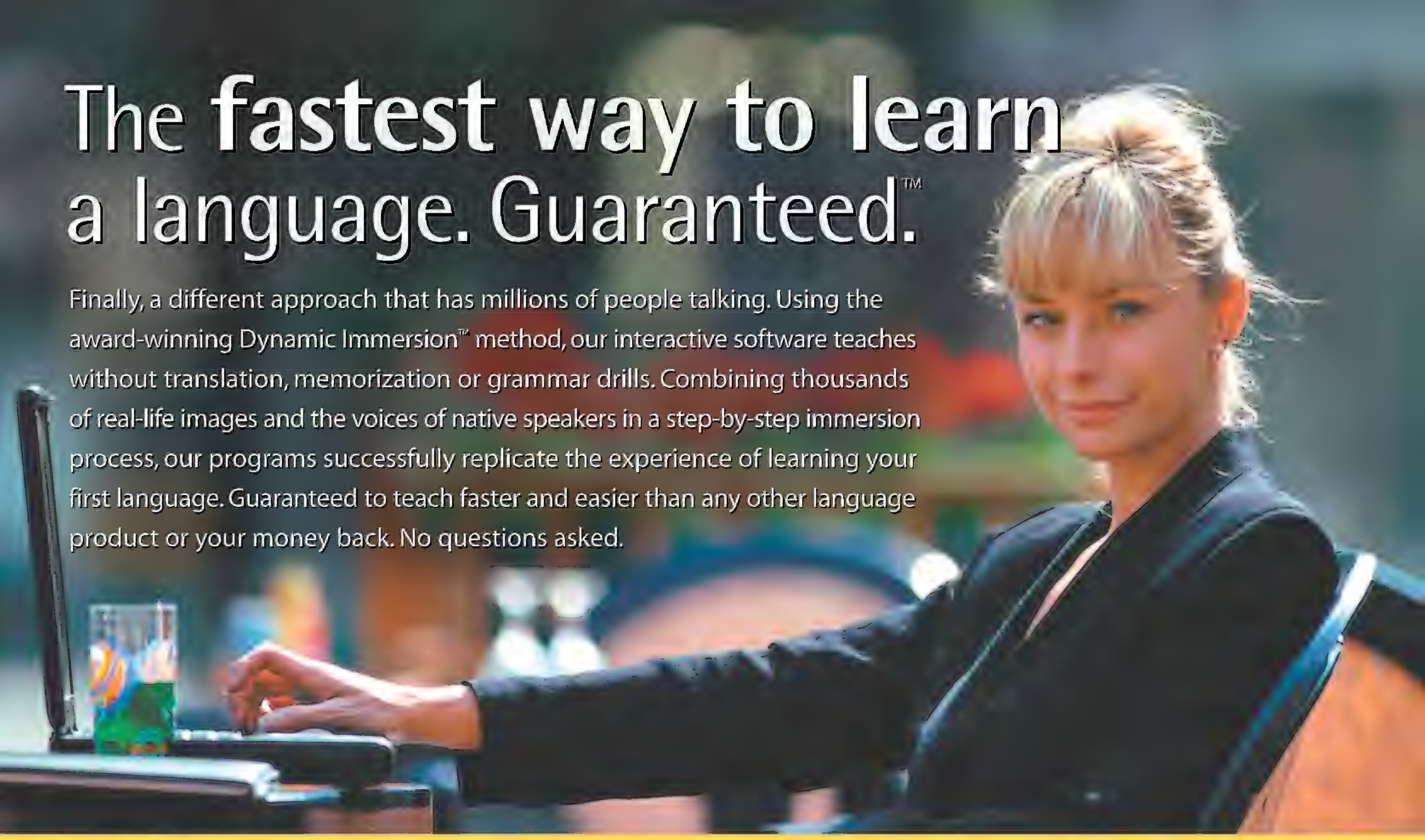
Myron Goff
Livonia, Michigan



"I'd answer them, but I can't forgive their canceling 'Father Knows Best.'"

Long Beach Loyalist

In late 1977, the Air Force selected the McDonnell Douglas KC-10A Extender over the Boeing 747 tanker variant to serve as a much-needed Advanced Tanker Cargo Aircraft (ATCA). The KC-10A has 88 percent



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commonality with the McDonnell Douglas DC-10-30 Convertible Freighter, and eventually 60 of the big three-holers rolled through the venerable Long Beach facilities. The Extender made its first flight in 1980, and soon after, KC-10As earned a reputation as a reliable part of the weapon systems mix. In addition, during production they provided a distinguished military presence among the national and international DC-10 orders in the factory.

Though Donald Douglas Sr. passed away one month prior to the Extender's March 1981 official entry into the U.S. Air Force inventory, I like to imagine he knew he had launched another winner.

Lt. Col. Charles E. Bailey
U.S. Air Force (ret.)
Placentia, California

"All of the passengers survived the accident (but just between you and me, only half were wearing clean underwear)."

Warnings to Nitpickers

In his review of *Hispano Suiza in Aeronautics: Men, Companies, Engines and Aircraft* (Reviews, Dec. 2004/ Jan. 2005), William Jeanes refers to "the 200-mph French SPAD XIII." I have three reference books that give the top speed of the SPAD XIII as 129, 134 and 139 mph. It is difficult to say which of those is accurate, considering that none of us was there.

Bill Hare
Mission, Kansas

When Captain Eddie Rickenbacker spoke to us naval air cadets at Pensacola, Florida, in 1952, he said the SPAD XIII was a 120-mph plane.

Donald Morris
San Clemente, California

The Dec. 2004/Jan. 2005 Letters section included a correction stating that the Curtiss Seagull did not have pontoons. That is true of the first Seagulls, such as the one described in "Contact" (Oct./Nov. 2004), but during World War II, Curtiss produced a version that could be fitted with a central pontoon and wingtip floats.

John P. Roberts
Dothan, Alabama

Editors' reply: A picture of that Seagull variant appears on page 69.

Boxed In

The artist who illustrated the "Hughes Air Force" poster (Oct./Nov. 2004) gave the Super Electra 14 an incorrectly boxy

cross-section. Compare the drawing with the photograph of the aircraft at the top of page 28 (same issue).

Grant E. Sorenson
Chippewa Falls, Wisconsin

It's a Jungle Down There

At least one of Carl Posey's abandoned aircraft is still around ("Jungle Graveyard," Above & Beyond, Oct./Nov. 2004). While stationed in Panama in the late 1980s, I heard of a B-25 in a lagoon off the obstacle course at Ft. Sherman. Two friends and I loaded up our scuba gear and went to find it, a task that proved remarkably easy: When I rolled out of the boat, I landed on the starboard vertical stabilizer! The aircraft was obviously placed there intentionally, as it had been thoroughly stripped of everything: control surfaces, engines, seats, instruments—nothing was left but the fuselage. Perhaps it was used as a training aid for rescue personnel. Despite its stripped condition, visiting the old warbird was a memorable experience.

Stephen Crane
Fayetteville, North Carolina

Corrections

Dec. 2004/Jan. 2005 Viewport: DeWitt Clinton Ramsey became Commander in Chief of the Pacific and the U.S. Pacific Fleet in 1948, not during World War II.

"Vital Signs": The U.S. airline industry was deregulated in 1978, not 1974.

"Basket Case" (Moments and Milestones): David Hempleman-Adams was not the first person to cross the Atlantic solo in an open-basket balloon. Joe Kittinger accomplished that in September 1984.

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All letters selected for publication are edited. We regret that we cannot respond to every letter.

Smithsonian
National Air and Space Museum

— MUSEUM DOCENT AGNES BROWN
Stands in front of the Douglas DC-3 on display in the Museum's Air Transportation Gallery. Her late husband flew this type of aircraft during the invasion of Normandy and the Berlin Airlift.

"OUR CHILDREN MUST KNOW THAT THE FUTURE IS THEIRS..."

Agnes Brown has spent her lifetime helping children learn and explore. It's very reassuring for her to know that the charitable gift she makes today will ensure excellent educational opportunities for children tomorrow. Mrs. Brown is a museum docent as well as a retired principal. She has an excellent perspective on what the Museum can offer future generations. That's why she's established two charitable gift annuities and a bequest with the Museum.

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A&S 03-05

Slow but Steady

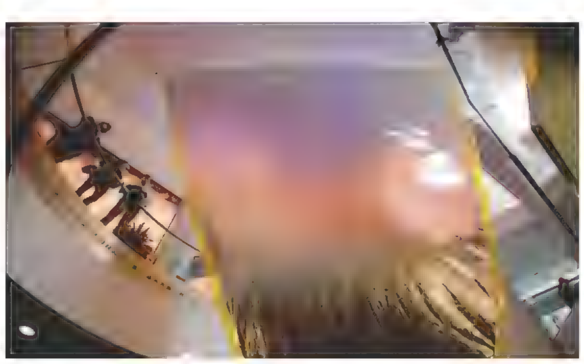
Sometime between March 1 and April 7, a Russian submarine will pause in the gray chill of the Barents Sea and launch a modified intercontinental ballistic missile. Crouched in the missile's warhead compartment like a spider, the payload will ride to an orbit 500 miles above Earth, shed its protective casing, and slowly unfurl eight shiny triangles of Mylar, forming a sail bigger than a basketball court. Then, if everything goes right, Cosmos 1 will become the first working solar sailcraft propelled to higher orbit only by the slight pressure of photons on its reflective sails—comparable to the pressure a postage stamp exerts sitting on your palm. The craft should be visible as a bright light moving slowly across the night sky. It may stay aloft weeks or even months.

Last year saw a flurry of activity in the field of solar sailing. The Japanese space agency and two NASA contractors each conducted tests of sail-unfurling systems. A business named Team Encounter even offered to send customers' DNA into deep space with a solar sailcraft, before its workers were laid off and its Web site was shut down. But the first organization to launch a solar sailcraft is neither a government agency nor a business. Cosmos 1 is a project of the Planetary Society, a U.S. nonprofit organization.

"I hope we're spurring on the notion that great projects can be done because the people of Earth are interested," says Louis Friedman, executive director of the society, "not just because it's an American thing or a NASA thing."

BELOW: PHILIP GREENBERG; BOTH: © THE PLANETARY SOCIETY AND COSMOS

The "wingtips" of Cosmos 1 outbound from Earth in an artist's conception (above), and a real wing on display in New York City (below).



Cosmos 1 makes use of some unconventional opportunities. Disarmament treaties make Russian ICBMs available for conversion to peacetime boosters. With contracted services from Russian organizations like spacecraft builder NPO Lavochkin, the budget is a dirt-cheap $4 million. That money comes from private donations ranging from $5 to several hundred thousand, and a roughly $3 million sponsorship from Cosmos Studios, a media production and science education company headed by Ann Druyan, the widow of Carl Sagan, author of PBS's "Cosmos" series and a co-founder of the Planetary Society.

The goal of the mission is both modest and audacious: the first controlled solar sail flight. It may not come easy. Submarine-based ICBMs have a mixed record as launch vehicles. One hoisted a German satellite into orbit in 1998, but in a 2001 test launch for Cosmos, the spacecraft failed to separate from the rocket.

Once in space, the spacecraft is vulnerable to micrometeorites and other hazards. Cosmos 1 is designed to demonstrate the principle of solar sailing and not much more. According to a Planetary Society spokesperson, the Mylar sails, thinner than a plastic garbage bag, will begin to degrade from exposure to sunlight within a month.

Finally, sailing in Earth's orbit, with the angle of the sun constantly changing, could be tricky. Propulsion and attitude control must be achieved by artfully balancing the force on the sails with gravity and orbital velocity. In theory, solar sailcraft can be made to "tack" toward the sun, and rise or sink in orbit.

"You can do maneuvers that you can't do with rockets," says Hoppy Price, a NASA engineer who once led solar sail design efforts at the agency's Jet Propulsion Laboratory in California. With sunlight as a free and constant source of fuel, and movable sails to influence the direction of the resulting force, solar sailers could hover over the North Pole or maintain orbits "levitated" beyond natural equilibrium points—tasks that for a conventional spacecraft would require an endless expenditure of propellant. That ability, says Price,

makes solar sails a cinch for government missions like Geostorm, which aims to position stationary sensors between Earth and the sun to provide warnings of solar storms.

The acceleration won from sunlight is underwhelming by rocket standards—Cosmos 1 might take 18 months to cover the same distance an Apollo mission traversed in three days—but it has the advantage of being continuous. Over time, craft with large, light sails could attain tremendous speeds.

Friedman clearly has those future trips in mind. He describes a harbor where gossamer giants set out for other planets or even, with the help of immense lasers, other solar systems. "This is the only technology we know of currently," he says, "that could someday take us to the stars."

—Martin John Brown

PEOPLE AT WORK

MARK AVINO

The Best Jobs in Aerospace

Eric F. Long
Senior Photographer
National Air and Space Division
Smithsonian Institution, Washington, D.C.

One of my most challenging assignments was capturing all the aircraft hanging from the ceiling of the Milestones of Flight gallery in one photo. I ended up lying on my back on the gallery floor at one in the morning. While it was not nearly as risky as shooting them in flight, it was certainly more time-consuming to photograph them 40 feet off the ground. Another assignment that turned into more of a stunt was shooting the cockpit of the Bell X-1 from a cherry picker 60 feet up.

One of the numerous perks of this job is the chance to travel far and wide to photograph the superstars of aviation and aerospace. In California, I donned a clean suit to shoot the powered-up cockpit of the space shuttle *Columbia*, being extra careful that my equipment didn't scratch anything. And I volunteered to cover all that went on behind the scenes at the Centennial of Flight celebration at Kitty Hawk in 2003—to bring back photos that told the story of that event, successful or not.

This is probably the best photographic job in the government. What I most love about it is not just the collection of mega-historic aircraft and spacecraft, but the challenge of photographing them creatively. My responsibility is to make an image that will withstand time.

Berlin's Oddest Attraction

Almost 50 years after Berlin fell to the Red Army, the ruins of a Nazi flak tower have become an unlikely stop on the tourist trek. Three-inch-thick steel cables dangle from massive, half-collapsed concrete walls. A rubble-strewn landscape curves into darkness. Stalactites hang from the ceiling.

After the gargantuan hulk had languished for decades in Berlin's Humboldthain Park, considered more of an eyesore than an attraction, the city's Underworld Society has opened it for tours. Visitors come for a glimpse at the remains of war, which all but disappeared from the city during the decades of economic prosperity fostered by the Marshall Plan.

"Meet me on the promenade of the old flak tower" is the latest hot tip for tourists in Berlin.

ALFRED KUEPPERS

Dietmar Arnold, chairman of the Berlin Underworld Association, used to play on the tower as a child. It took decades to achieve his goal of opening the site so that visitors could learn about the city's darkest chapter.

"Before, the city senate was against us. It was considered somehow improper to go poking around in places like this," says Arnold, decked out in a bohemian Berliner's black sweater and gray cap. "But over time, even they have recognized we are doing something good for the city."

Hitler originally wanted to defend Berlin with six such constructions, but after funds ran short he settled for three. The British and Russian occupiers blew up the towers in their sectors after the war, but totally destroying the Humboldthain fortress proved impossible.

The French made two attempts at taking down the eight-foot-thick steel-reinforced walls, then decided it was too dangerous to detonate a third charge in the half-ruined building. Instead, they landscaped the site. It is now half flak tower, half wooded hill, and almost fully camouflaged.

The tower was sophisticated for its time. A nearby radar installation recorded the location of Allied aircraft and relayed the information through cables to eight 128-millimeter cannon mounted on top of the 70-foot-high building. The cannon automatically sent flak in the direction of the attacking aircraft. One level below, the Nazis placed 37-millimeter cannon to fire at low-flying aircraft.

"They managed to shoot down twice as much metal, in terms of enemy aircraft, as they put up into the sky," Arnold says. "So even though Berlin was the most heavily bombed city during the war, it wasn't the most destroyed."

—Alfred Kueppers

Phantasia

"It's like our own private airshow," says Steve Eisner, vice president of the F-4 Phantom II Society. "Basically, we work with an F-4 unit to host us so we can celebrate the airplane. Because we're housebroken and behave ourselves, the military are very good to us and let us visit their playground."

Eisner is talking about Phancon, the society's nearly annual convention. Last year's event was held on October 20 to 22 at Holloman Air Force Base in New Mexico. Holloman has the largest number of flying Phantoms in the United States, with a squadron of German air force F-4Fs and a U.S. Air Force detachment of QF-4 target drones.

With 150 "phanatics" attending, including nearly 50 from other countries, Phancon is a far cry from a simple gathering of former F-4 air and ground crews. In fact, the vast majority of the society's 900-plus members have no direct connection with the hulking McDonnell fighter. Justin Messenger, a lawn care service owner from Arkansas, says merely, "It's just a dang neat airplane!" So neat, in fact, that he built his own simulator, complete with cockpit mockup and projection screen visual effects.

Phancon is all about camaraderie, with the F-4 serving as the foundation. Doc, a heavy-equipment operator from Philadelphia, discusses the finer points of difference between the C and D models with Arno Biijmark, one of a number of Dutch attendees. Ex-Royal Navy men describe the experience of launching a K model from the icy deck of an aircraft carrier above the Arctic Circle: "Bloody cold, but bloody marvelous at the same time!" Alex, a young man from Miami, recalls watching F-4s at nearby Homestead Air Force Base as a child.

KEVIN JACKSON

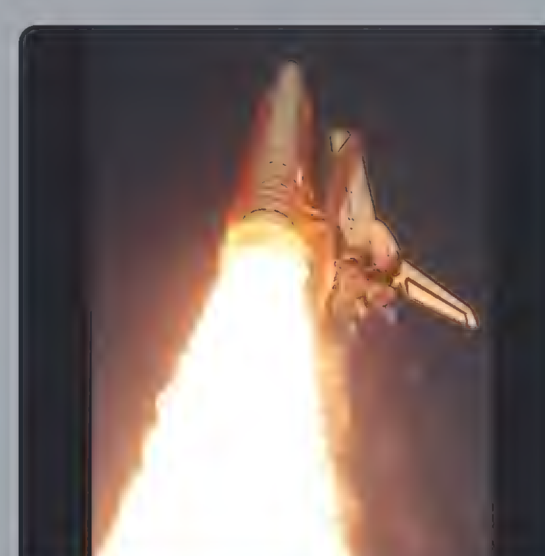
F-4 enthusiasts take in the sights at Holloman Air Force Base's Phancon.

Granted remarkable access to the flightline and crews at Holloman, the phanatics come equipped with a staggering variety of camera equipment. Model builders, aviation photographers, and aircraft slide collectors all have their reasons for snapping Phantoms and spare no expense. A quartet of Swiss phanatics, with more than 20,000 slides among them, was particularly ferocious in trading with several of the commercial photo vendors.

BAR BETS

Why does the space shuttle roll 180 degrees after it launches?

Because the antennas on the belly of the orbiter are blocked by the external tank and the solid rocket boosters, the orbiter rolls to point the antennas on its top surface at tracking stations on the ground during ascent. This is necessary because the orbiter is mated with the tank and boosters in the Vehicle Assembly Building and is moved to the launch pad on the massive Crawler/Transporter, which has no place to turn around en route, so the shuttle stack arrives at the pad facing the same direction as it was when it left the VAB. Rather than add an expensive turnaround capability to the Crawler, NASA simply turns the shuttle stack right after launch.



KSC/NASA (3)

The keynote speaker, retired U.S. Air Force Brigadier General Robin Olds, a World War II and Vietnam War fighter pilot with 13 kills in his first conflict and four MiGs in his second, has near-rock-star status within the fighter community in general and the F-4 Society in particular. During his presentation, he reminded the audience the F-4 was built as a war machine, pure and simple. "I've flown her when she was angry and I've flown her when she was playful," he said. "No matter what her mood, I enjoyed the experience. I was a lucky man."

Jack Callaway, last year's event coordinator, summed up the obsession with the Phantom this way: "All angles bent up, bent down, that long nose, the roar of J-79s at afterburner takeoff—it's just an unbelievable experience."

This year's Phancon is planned for Davis-Monthan Air Force Base in Arizona, a vast military aircraft storage site where many Phantoms have ended their careers. Future events may be held in those countries where F-4s still soldier on: Germany, Turkey, Greece, Japan, and South Korea.

—Braxton Eisel

WE HAVE LIFTOFF

Delta Dawns

Though it carried little more than dead weight, the debut flight of Boeing's heavy-lift Delta 4 last December 22 has major significance for U.S. space programs. Now that the Titan 4 launcher is being retired, the military wants the monster Delta booster to heave spy satellites into orbit. NASA is also looking at the Delta 4 Heavy, which can carry shuttle-class payloads, as an option to launch its next generation of manned spacecraft to the space station and possibly the moon. Boeing, which suffered back-to-back failures on Delta 3 inaugural flights in 1998 and 1999, is just happy the rocket is off the ground. The booster spent more than a year on the launch pad, waiting out three hurricanes and a spate of technical problems. Said Colonel Mark Owen, Air Force 45th Space Wing commander, prior to the flight, "It's going to be a spectacular launch, certainly, in one of two ways. We hope it will be positive."

On the debut flight, the test satellite did not reach its targeted orbit due to an underburn of the Delta 4's first-stage engine. Nevertheless, Boeing said the major objectives of the test flight were achieved and the company is moving ahead with plans to fly a military communications satellite.

SCOTT ANDREWS

—Irene Klotz

WORK IN PROGRESS

COURTESY K.P. RICE

One of the prime movers behind the North American OV-10 Bronco, K.P. Rice, is building a prototype of what he calls the Volante Flying Car in Santa Ana, California. Rice plans to offer it to homebuilders in kit form as a two-seat composite recreational vehicle with a gross weight of 1,850 pounds. Rice says both aircraft-to-car and vice-versa conversions can be accomplished by one person in under 10 minutes. A Lycoming O-320 150-horsepower engine will enable a cruise speed of 150 mph and a normal highway speed when the flight hardware is towed behind the car. A 45-gallon fuel capacity translates to an air range of 600 miles. Test flights are being conducted at California's Mojave Airport, a hotbed for entrepreneurs. If a homebuilt suborbital spacecraft can succeed, can a flying car do likewise?

One-Man Band

How many people does it take to create a flight simulator accurate enough to help develop an airplane?

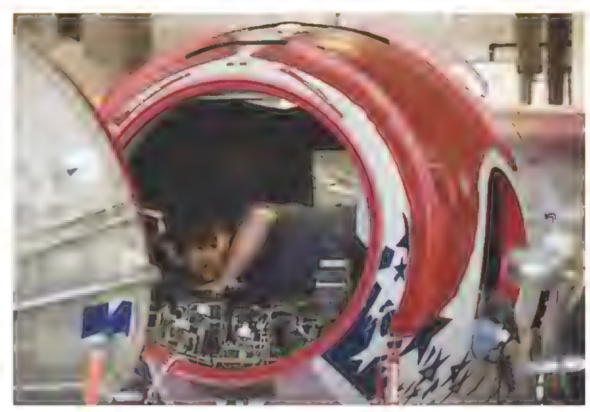
Three, according to conventional wisdom: An engineer to model the aerodynamic performance, a computer programmer to write the code, and a test pilot to validate their work.

Or you could go to Pete Siebold, who did all of the above all by himself.

Siebold was one of the three Scaled Composites test pilots to fly SpaceShipOne, the first privately funded craft to carry a person into space. He also created the simulator that led to fellow test pilots Mike Melvill and Brian Binnie earning astronaut wings last year.

Scaled founder Burt Rutan was reluctant to develop a sim in-house. But he soon realized that existing programs wouldn't work because they couldn't simulate long durations of vertical flight or the effect of rocket motors, much less maneuvering at 320,000 feet.

Siebold, 33, is a rare test pilot who also understands computer programming. After Scaled aerodynamicist Jim Tighe fashioned the aero model —a mathematical representation of aircraft performance—Siebold wrote the code that created a virtual version of SpaceShipOne and coupled it with an off-the-shelf graphics program to build a personal-computer sim. Later, he used that as the basis of a second, more sophisticated simulator housed in a full-size mockup of the SpaceShipOne cockpit.



MARK GREENBERG/WORLD PICTURE NEWS

Pete Siebold in the belly of the beast.

Pilots access the sim by crawling past a tongue-in-cheek warning: "Please keep all hands and feet in the space ship at all times." The flight data display mounted in front of the seat is identical to the unit in SpaceShipOne. So is the joystick, originally designed for cropduster aircraft. The side windows feature monitors displaying images created by 10 computers. The four front windows are filled by a rear-screen projector.

Before the spaceship took off, the simulator helped the pilots understand what they could and couldn't do in the various regimes of a suborbital flight. "For example," Siebold says, "we found out that it was critical to pull up immediately after lighting the rocket." Otherwise, he says, SpaceShipOne would go too fast in level flight.

—Preston Lerner

NASM CSI

When American service men and women go missing during conflicts, the government agency charged with identifying and recovering their remains is the U.S. Joint POW/MIA Accounting Command (JPAC), a joint-services operation headquartered at Hickham Air Force Base in Hawaii. Six JPAC investigation teams monitor news reports, tips from family members and buddies, rumors—anything that might lead to a missing American—and 18 recovery teams are ready to trek to the far corners of the world to check out the stories. The investigators and recovery teams are often called to the sites of wrecked aircraft, where they sometimes come across airplane parts they can't identify. And for more than two years, JPAC has turned to the National Air and Space Museum for help in identifying the bits and pieces of unknown origin that turn up in the course of their work.

Aaron Lehl, a civilian analyst and one of the more than 425 people who work at JPAC, recalls that he first contacted the Museum in the summer of 2002. A JPAC team had come upon some wreckage in Papua New Guinea and photographed remnants of some radial engines. But whose? "Sometimes there's a paucity of evidence and we can't ID the aircraft," Lehl says. "If we can get a photograph, we can transmit it to the folks at the Museum, and they'll tell us what kind of aircraft it is."

The images ended up on the desk of aeronautics curator Jeremy Kinney, who in turn sought an opinion from Rob Mawhinney, an engine expert at the Museum's Paul E. Garber restoration facility. "From what I saw: the pushrod tubes, the supercharger design, the cylinder design—and more important, the bolt patterns, the number of [cooling] fins, the shape of the [cylinder] head—it was a Japanese-built Sakae," Mawhinney says. "That was a big help to us," says Lehl, "because we might have sent a [recovery] team, and this saved us the effort and cost of that."

An almost complete engine is one thing, but fragments and shards can pose more of a mystery. Lehl contacted Kinney on one occasion following publication in a Chinese newspaper of a photograph that seemed to show a U.S.-built part, but there wasn't much to go on. Chinese sources said the part came from a burial site near a village whose residents said the grave dated back to World War II. Within a day, Kinney was able to relay the word that the part came from a U.S.-built Curtiss P-40. The ability of the staff to sleuth out the airplane type is what keeps Lehl coming back.

ERIC LONG

Curator Jeremy Kinney (standing) and Garber guys Larry Wilson, Bill Reese, and Rob Mawhinney (left to right) help identify wrecked military aircraft.

"All we got was what looked like a trim handle and a data plate with some serial numbers," recalls Bill Reese, who is on Garber's crack team of detectives. "We could also see it was a Curtiss product, and the location of it led us to the P-40." So Reese handed the case off to Larry Wilson, Garber's master tracer of serial numbers. "P-40s were built as Curtiss Model 81s—the Tomahawk for the Brits—and the P-40 Bs and Cs were the ones operated by [General Claire] Chennault and the Flying Tigers," Wilson says. "But this was a Model 87 series part, which was the designation for the later Model D. When I started looking through the earlier model parts catalogs, I was finding 87 series parts in them, so that resolved the [apparent] conflict." The part was confirmed to be from an early model P-40.

"All we got was what looked like a trim handle and a data plate with some serial numbers," recalls Bill Reese. "We could also see it was a Curtiss product, and the location of it led us to the P-40."

"So if there are [human] remains at the site, I now knew I was looking for a P-40 [pilot]," says Lehl. "I still had to go through 80 records, but without that identification, I'd have had to search hundreds."

JPAC's work is intended primarily to provide closure for the families of those who were missing, and is not reported widely. In a typical year, the staff handles 40 to 50 cases and dispatches seven to 10 recovery teams. A team may be in the field for up to 45 days at a time, and over a year can spend a total of five or six months in some of the most remote areas in the world.

"While the accounting process may take years," reads its mission statement, "JPAC remains committed to scientific excellence and the fullest possible accounting of all Americans who died in the defense of their country. JPAC continues to fulfill our nation's promise to the POW/MIA families and their missing loved ones. Until they are home."

Jeremy Kinney and the team at Garber find the work they do for JPAC rewarding. "We like to hear from them so we can help them," says Kinney. "In most cases, they're thanking us and we're turning around and thanking them for letting us do it," Reese says. "It's more satisfying when we can say the crew survived and [JPAC doesn't] have to pursue it," Wilson adds. "But any way we can help, it's wonderful." Mawhinney sums it up this way: "To me it's a noble endeavor. You can't repay these guys for what they did for their country."

Lehl says he usually contacts Kinney when he's out of ideas. "I contact them with the hard cases, and they've never failed me yet."

—George C. Larson

ARTIFACTS

DANE PENLAND

The National Air and Space Museum's Redstone surface-to-surface missile was donated by the U.S. Army in 1978, and after 26 years of being stored disassembled in two trailers at the Paul E. Garber restoration facility in Suitland, Maryland, the Redstone went on display at the Steven F. Udvar-Hazy Center in northern Virginia last September.

Putting the Redstone in place could not begin unti 5:30 p.m., when the Udvar-Hazy Center closes to the public, and crane crews worked until 1 a.m. to right the 69-foot missile, which was built by the Chrysler Corporation's missile plant in Michigan. It was not until Museum specialists removed the Redstone from its trailers that they realized that the missile was a cutaway, with some panels of skin removed along the length of the artifact. Museum curator of rocketry Frank Winter was pleasantly surprised: "A cutaway is ideal since most people love to see what is inside of things." Designed to carry either a conventional or a nuclear warhead, the Redstone spawned variants that launched the first U.S. satellite, as well as astronaut Alan Shepard, the first American in space.

VISITOR INFORMATION

Location The National Air and Space Museum is located on the National Mall, along Independence Avenue SW between 4th and 7th Streets, Washington, D.C. The Steven F. Udvar-Hazy Center is at 14390 Air and Space Museum Parkway, Chantilly, Virginia, near Washington-Dulles International Airport.

Hours The Museum on the Mall and the Udvar-Hazy Center are open from 10 a.m. to 5:30 p.m. every day except December 25.

Food The Museum on the Mall has the Wright Place Food Court, which offers selections from the menus of McDonald's, Boston Market, and Donatos Pizzeria. The Udvar-Hazy Center offers food service from Subway (sandwiches, salads, chips, cookies, and drinks), located at the south end of the main hangar.

Shopping Both the Museum and the Udvar-Hazy Center shops offer a variety of souvenirs, books, DVDs, models, posters, clothing, and toys. A selection of these products can be purchased online at *SmithsonianStore.com.*

Donald D. Engen Tower The Udvar-Hazy Center has an observation tower from which visitors can watch air traffic arriving at and departing Washington-Dulles International Airport. The only way to access the tower is via an elevator that rises 164 feet above the ground. The elevator can transport 15 people every five minutes.

IMAX Theaters View Earth from the open cargo bay of a space shuttle, experience the thrills of flying a fighter, and journey to natural wonders at the Museum's Lockheed Martin IMAX Theater and the Udvar-Hazy Center IMAX Theater, where large-format films are projected onto a screen five stories high. For information on tickets and showtimes, call (877) 932-4629.

NASM Express Shuttle Bus A shuttle runs round-trip between the Museum and the Udvar-Hazy Center from 9 a.m. to 5 p.m. Tickets cost $9 to $12, depending on visitor age and number in party. They sell out quickly, so visitors are encouraged to purchase them in advance at (202) 633-4629.

Rogue Elephants

Seventeen years ago, I spent a Sunday morning strapped to the left ejection seat in the lower deck of a B-52G as it flew at treetop level over the wilds of Alaska. With the skies above us roaring with F-4s, F-16s, and F-15s frantic to find and engage us, we penetrated hundreds of miles to strike a target and destroy a myth. The air defense brass expected a turkey shoot, but what they got was a wake-up call that sounded like this: "B-52, 51 bombs away!" I know. I made the call.

Officially, Amalgam Warrior was a large-scale exercise in air sovereignty and air defense, usually involving two or more North American Air Defense regions and employing electronic warfare and other penetration tactics. Unofficially, it was a week of kick-ass war games, with a variety of military aircraft mixing it up in 20,000 square miles of military operating airspace.

B-52s were integrated into the Amalgam Warrior scenarios to replicate the threat posed by enemy bombers. In 1988, the United States still maintained a 24/7 nuclear alert. The Soviets were fielding a dozen new supersonic Blackjack bombers to augment their fleet of subsonic Bear bombers, and intelligence on the Blackjack stressed its low-level penetration capabilities and its enhanced electronic countermeasures.

The 668th Bomb Squadron, part of the 416th Bombardment Wing at Griffiss Air Force Base, New York, took its turn being the Red team that year, sending three B-52G bombers, six aircrews, and support staff, under the command of Colonel Jim Richards, to Alaska's Elmendorf Air Force Base, which hosted the exercise. The crews rotated, flying about every other day, with mission planning between flights. A practice preceded the actual exercise.

I loved being a B-52 radar navigator. When I completed navigator training at Mather Air Force Base in California, I had my choice of navigator assignments. To the surprise of many Mather instructors, I passed up fighters and chose B-52s. When I graduated from B-52 training at Castle Air Force Base, California, and reported to Griffiss, I believed I had the best job in the entire Air Force. By 1988, I was an instructor radar navigator (bombardier) with a crew well versed in tactics and coolly professional. Our trust in one another's skills, experience, and judgment made us extremely effective.

And therefore it was extremely frustrating when our initial role in Amalgam Warrior was to pose as ducks in a shooting gallery. While B-52s were on the Red team, it was obvious we were not much more than a sentence or two in the mostly fighter playbook. We had one play: Go deep. The target deepest in the exercise area, an airfield accessible only after flying through a wall of Airborne Warning and Control System-directed F-4s, F-16s, and F-15s, was ours. Fine by us—provided we could do what we do best. Instead, the exercise restricted us to flying a three-ship cell, two-mile spacing, at 1,000 feet. One thousand feet? What kind of low-level was that? But it got worse.

B-52s were permitted limited electronic countermeasures, minimum threat maneuvers, no communications jamming, and nothing that would "complicate" engagements. We were fine with the go-it-alone strategy, but it was the fly-straight-and-level-so-we-can-shoot-you rules that annoyed us.

If flying under such restrictions was frustrating, the debriefings that followed were downright humiliating. I remember the colonel who led the Blue forces walking up to the podium and making a wisecrack about hunting elephants. The first slide he showed was a cartoon of an elephant on its back, labeled "B-52" and bearing dozens of little arrows. A fighter pilot, he joked that the only aircraft that didn't record a B-52 kill was a bush plane that strayed into the airspace by mistake. The whole room—minus our small group—erupted in laughter. Then, as he took away the overhead, he patronizingly thanked the B-52s for being good sports. "Not everyone would come up and take such abuse," he added.

At the club bar, it was hard to stomach the flak. I took a few jokes from fighter egos, tolerated a few condescending questions, and smiled my way through crowds that generally ignored a bomber guy. I wondered if they thought this was a good test of their skills. Would the Russians attack at 1,000 feet, flying straight and level? What did we prove by cheering results that were fixed?

> His first slide was a cartoon showing an elephant, labeled "B-52," on its back, feet in the air, bearing dozens of little arrows. A fighter pilot, he joked that the only aircraft that didn't record a B-52 kill was a bush plane that strayed into the airspace by mistake. The whole room erupted in laughter.

The day before the war game started, Colonel Richards dropped by our crew lounge. The same humiliating scenario had been played out day after day in the practice phase, and he had stayed quiet. Now he listened patiently to our pleas to

provide a more realistic engagement. His response stunned us. He commented that it appeared our hosts did not know what we were capable of and that we should take the lead in representing the threat fairly to maximize the training value to all parties. Then he turned to me and asked, "Is that something your crew could handle?"

The room fell silent. "Sir," I said, "did I hear you correctly, that you want us to prepare a new strike plan for tomorrow?" He replied, "What I'd like to see is what you believe we are capable of flying. Brief me in the morning. Goodnight, gentlemen."

Mission planning on no notice was a way of life for bomber navigators. After a quick call to the two other B-52 crews who would be flying with us the next day, Plan B started coming together. We redrew charts, reworked timing, reevaluated radar aim points and terrain features, and discussed jamming and electronic countermeasures plans. We would hit the target from three different axes of attack and tighten the timing to 30-second spacing. Blue forces knew when we were coming, from what general direction, and even approximate target times, but we had a few advantages of our own. Surprise was the first. The fighters were expecting the same defenseless, predictable pattern they had seen all week.

Our second advantage was autonomy. We didn't need outside guidance or input. Blue fighters were not so independent. They relied heavily on air controllers from ground sites or from the Airborne Warning and Control System to vector them into intercept position, as well as keep them in their assigned airspace. We were about to cut their phone cord.

A third advantage was our comfort at low altitudes. We trained at it extensively, in all terrain, day and night, because our mission demanded it. B-52s were part of a nuclear retaliation plan in which the bombers would often fly at or below 200 feet for extended periods to hit Warsaw Pact and Soviet targets. Fighters, by comparison, spend only a fraction of their training at low altitude. Elmendorf F-15s, for example, annually trained just one-quarter of one percent of their time at 1,000 feet or lower. On the deck, it was Advantage: bombers.

The next morning we briefed Colonel Richards. He gave us the go-ahead for the new routing but wanted to think about our request to fly below 1,000 feet. We told him that was critical and we could do it safely. A few hours later, at the Red forces pre-brief, he delivered his usual remarks with one notable exception. "Sir, are we held to 1,000 feet?" my pilot asked. "Gentlemen," Colonel Richards responded, "fly safe, fly well, but fly where your abilities allow." The room snapped to attention.

The sortie we flew that day was memorable, if I may say so myself. We hit the entry point and dove for the deck. Once we were down to 200 feet, we split and went lower. Now there were three B-52s flying in three directions, with frequent heading changes, crossing routes, and jamming communications. Low-level flying in a B-52 is a well-orchestrated medley of inputs and shifting priorities. There are navigation calls, terrain calls, threat calls, maneuvers, clearing, timing, checklists, equipment, and more. It is intense and yet, as training and instinct take over, surprisingly calm.


©JIM BENSON/CHECK-SIX

Our aircraft's first encounter was with an F-4 that we sucked into our tail-gunner's crosshairs. That was followed by an F-16 chasing us across some of the most rugged terrain in the area for 45 miles without getting off a shot. Finally, F-15s flying over the target never saw us roll in off the ridge line until my "Bombs away" call. Periodically, breaks in communications jamming revealed considerable Blue force cursing, frantic requests for vectors, and an inevitable "No joy!"

In a windowless realm, you use everything you have to get bombs on target. I had primary responsibility for clearing terrain, delivering weapons, and overseeing navigation and split-second timing tolerances with the navigator. In the days before the Global Positioning System, we had to work to stay on course and on time. Keeping the dual inertial navigation systems accurate required taking radar fixes periodically. However, rolling a crosshair onto the radar reflection of a metal tool shed at 450 knots and 200 feet while maneuvering to avoid threats is a daunting task. To acquire the target, I augmented the radar with the forward-looking infrared camera and the low-light-sensing camera. By the time the bomb bay's doors closed as we came off the target, the F-15s could have found us just by the volume of our shouts of glee. The turkeys had trumped the eagles.

At the debriefing, the same colonel who days before was laughing it up with elephant cartoons now came to the podium red-faced and furious. He threw down his cap and launched into a tirade on how the B-52s had cheated, had not done what they were supposed to do, had not played fair. His overhead-shot slide was a little thin when it came to B-52 kills—in fact, it was anorexic. Instead of dozens of confirmed kills, he could show only a single shot, taken at the bomber's nine o'clock position, from one mile out, with the bomber at less than 100 feet—and outbound. "Outbound" was the key word—we had been able to hit the target and were heading for home before a lone defender took a desperation shot.

At the bar that afternoon, lots of aviators came over to talk about what we did and how we did it. Some were angry, some were impressed, and some were in denial. The F-4 pilot said it looked like a mountain had shot up in front of him when we slammed on the brakes and sucked him into our gunner's range. The F-16 pilot said that was the most impressive low-level flying he had ever seen. He also confessed to being so focused on trying to get a shot at us that he lost track of his position and was fragged—shot by his own team. The F-15 drivers complained we hadn't played fair.

Neither would the enemy, we said. Yes, we bent the rules that day. We attacked the status quo and did what no one expected us to do. We won. But in fact we all won, because we are only as strong as our weakest link.

And the Coronas tasted a hundred percent better that evening.

—C. James Novak

My Adolescent Aviator

BETH MLADY

He isn't even old enough to drive, and yet budding pilot Jason Mlady manages to fly an airplane with the aplomb of a pro.

Jason smiles and devours his breakfast, careful to swipe away crumbs from his chin before adjusting his "I'd Rather Be Flying" hat. I try unsuccessfully to swallow a piece of toast. It is Saturday, the skies are a pristine blue, and Jason's flight instructor waits at the lakefront airport.

My 14-year-old son grabs his logbook and dashes to the car. "Why do I put myself through this?" I ask, but I already know the answer. He loves flying. It's that simple.

Jason's passion was ignited after he spent a week at aviation summer camp at Wright State University in Ohio two years ago. When he went on to take an introductory lesson last fall, I told myself it would be a mere flight of fancy. A couple of minutes of retching into a bag, and his love of all things aeronautic would pass. It didn't. "The turbulence was awesome," he gushed. Not helping my cause was his first instructor—an attractive young woman. Jason's hormones are now costing me a fortune.

I should have recognized his interest in flying sooner. His grandparents finagled a tour of a Boeing 747 cockpit for him in 1992 as they boarded a flight when Jason was two. "Your son is so cute," said the captain. "Can he come aboard for a few minutes?" When Jason was four, we flew kites together. He questioned how a kite could float like that; why pulling the string made it soar even higher; why it needed a tail. He also asked why Charlie Brown always got his kite stuck in a tree.

Jason learns more than aerodynamics when he takes to the skies. His sense of responsibility and level of maturity soar as well. Boys his age often struggle with who they are and where they fit in to the grand scheme of life. Jason is already well on his way to understanding those things.

His air traffic control scanner clicks on and off in his bedroom every day. The door is shut, of course—"I'm 14, Mom. I need my privacy." What he hears in those garbled radio transmissions fascinates him. I should be thankful, I suppose, that he chooses to listen to static rather than the Screaming Hangnails or whatever music is popular with kids these days.

When Jason realized that the airplane carrying President Reagan's body from Washington, D.C., to California would miss our airspace and that consequently he would not be able to hear radio transmissions from the pilot of Air Force One, his disappointment was tangible. I never imagined he had the capability—or the desire—to experience part of history from a radio in his bedroom.

His mail consists of aviation supply catalogs, from which he has compiled Christmas lists for at least the next seven years. Jason pores over them and flight magazines for hours when he is not immersed in his computer's flight simulator.

Flying takes him away from all annoyances—parental rules, school regulations, little brothers—that he feels tie him down. With the wind under his wings, he forgets whatever adolescent problems beleaguer him on the ground. He may not yet realize that a piece of his life's puzzle drops into place every time he clears the runway. The airplane gives him a satisfying feeling of control—over the machine and, more importantly, himself.

Jason handles pressure well, another skill acquired only through life experience. During one flight, the radio malfunctioned. His instructor tried to make contact with the control tower. Sunlight against the tower's windows made it impossible to discern the color-coded light that the controller used to convey clearance for landing. My son and his teacher did an intense visual search of the skies for other air traffic, and Jason never hesitated at the controls as he landed the airplane safely. His instructor that particular morning, a recent college graduate new to the flight school, appeared rattled afterward and in need of a gin and tonic. Jason, however, shrugged his shoulders, smiled broadly, and sat down to update his logbook.

I must let Jason fly because he continues to ask why. As a pilot's mother, my role is to help him find his wings and soar. I will swallow the lump in my throat, breathe deeply while he starts the engine, wipe my palms against my jeans as he taxis down the runway, and wave goodbye with a nervous smile frozen on my face.

—Beth Mlady

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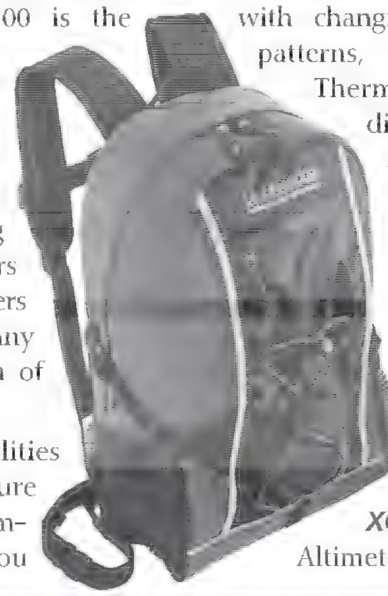

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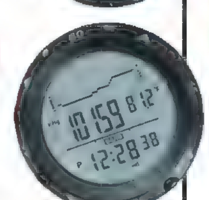

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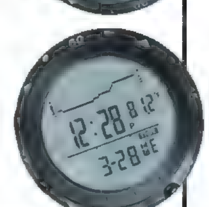

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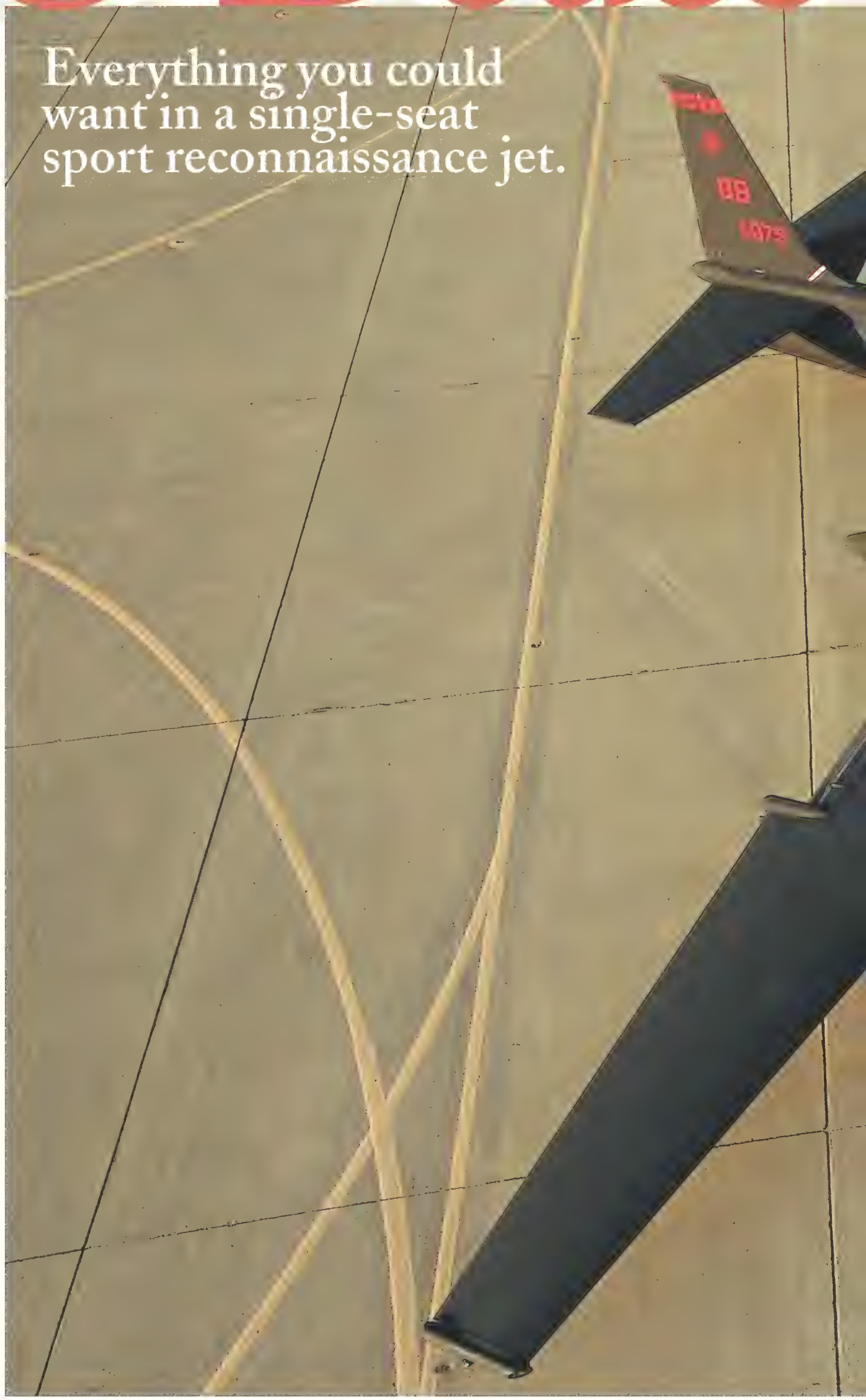
The U-Deuce

Everything you could want in a single-seat sport reconnaissance jet.

By William E. Burrows

Photographs by Chad Slattery



"The airplane is nothing like what Powers flew," says Bryan Swords, currently the chief engineer for the U-2S at Lockheed Martin Aeronautics Company's Palmdale, California office. Swords is referring, of course, to Francis Gary Powers, who, four years after overflights began over the U.S.S.R., Poland, and East Germany, had the unfortunate distinction of being shot down in a U-2 near Sverdlovsk in the Soviet Union on May 1, 1960. "It's 40 percent larger, it's been re-engined, it's got a new cockpit, and it's been rewired to support extremely modern, stronger sensors," says Swords.

The U-2's adaptability has kept it in service since the mid-1950s and should keep it off the endangered species list for another half-century. The airplane originated as a response to a desperate need for reconnaissance over the Soviet Union and Eastern Europe. Bell, Fairchild, and Martin were among the firms invited to submit proposals. But when he heard about the competition, Clarence L. "Kelly" Johnson of Lockheed submitted a design as well. Johnson was the chief engineer at Lockheed's Skunk Works in Burbank, California, and his entry was basically a powered glider based on a modified F-104 Starfighter fuselage mated to very long wings and a centerline landing gear. The CL-282, as it was called, was a simple and adaptable reconnaissance platform. The Air Force promptly rejected it, but the CIA grabbed it up and code-named it Aquatone. It first flew in 1955.

Today, the aircraft has a new name: Senior Year, and many of its systems have the prefix Senior, as in Senior Ruby and Senior Glass. Less officially, the large, black, sinister-looking spy-

Deuce

The U.S. Air Force's 9th Reconnaissance Wing at Beale Air Force Base in California flies the U-2S.

craft is known as the Dragon Lady.

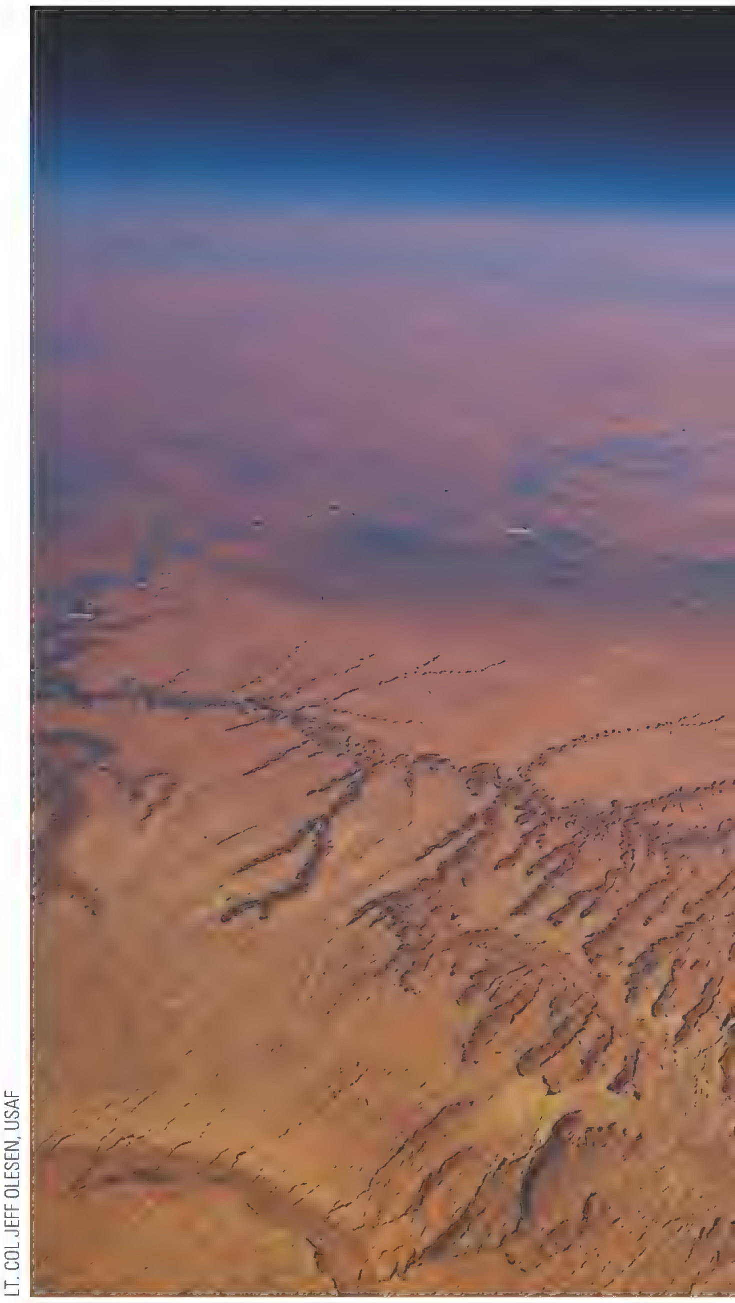
Even from the start, the U-2's evolution has been driven by its sensors. "The Air Force comes to us with a capability requirement," says Mark A. Mitchell, Lockheed Martin U-2 program office manager. "There's a new sensor out there, a new operational concept, and they want the airplane to be able to support it." Mitchell's job is to respond to the Air Force's wants in a rapidly changing world. During World War II, he says, a large military target or a city would be photographed by speedy, high-flying reconnaissance airplanes and then hit by hundreds of heavy bombers. That mode of operation continued into the cold war, though with one change in plan: If there were a U.S.-Soviet exchange, just a few bombers would be deployed, with nuclear bombs.

But the link between reconnoitering a target and attacking it is undergoing a revolutionary change. The new way of doing things is called network-centric, or net-centric, warfare. The military is turning reconnaissance systems into an information network like the Internet, in which all the image and signals collectors are connected to one another, as well as to the combatants in the air and on the ground. Soldiers searching for Al Qaeda forces in Afghanistan, for example, can now send a request to task a nearby reconnaissance satellite to scour the area, and can download the images it captures to their laptops and see them in seconds. If it's urgent, a U-2 in the vicinity could be directed to fly in for a closer look. And if the U-2's sensors confirm what the satellite saw, the troops know it almost instantly. The Department of Defense calls this arrangement the Global Information Grid, and it is in continuous operation around the world.

A ground operations center on the other side of the world can also direct the intelligence collectors to get specific data, provide aircraft navigation instructions, operate the sensors, communicate with the aircraft, with satellites, and with other collectors, and then direct the collectors to communicate with one another to share information and to deliver the intelligence to soldiers, sailors, or marines. The military calls this "fused" intelligence, and well over $1 billion is being spent to fully integrate the Dragon Lady into the system.

To take sensor management as an example, technicians at control panels thousands of miles away can direct the sensors while its pilot looks on (his main job is to fly his aircraft). Using a satellite to relay the data, a U-2 looking and listening deep inside North Korea sends its take back to the United States. And it gets its instructions from controllers at home the same way.

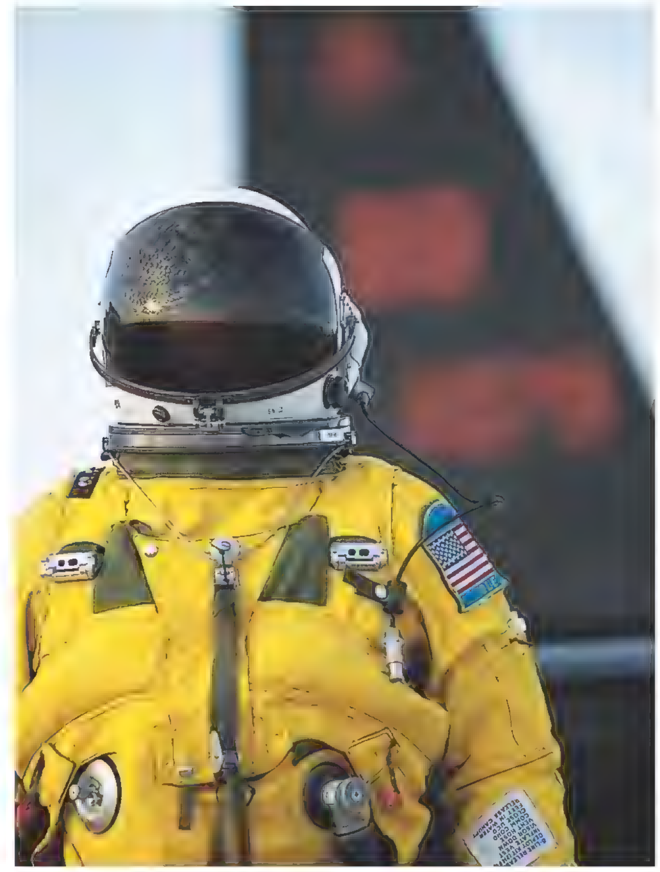
What has changed dramatically, Mitchell adds, is that a single U-2 can train an array of sensors, including



LT. COL. JEFF OLESEN, USAF

The old cockpit, with its central telescope (below), is out; "glass cockpit" video screens are in.

LEFT: JOE OLIVA/JETPIX; RIGHT: PETER A. TORRES/LOCKHEED MARTIN



At 75,000 feet, near the edge of space, the sky is black (left) and pilots like Lieutenant Colonel Jeff Olesen (above) wear pressure suits and pre-breathe oxygen for an hour as if they were heading for orbit.

imaging systems, antennas, and receivers that intercept radio signals, on a target. Then that information can be sent directly and immediately to a single F-16 pilot, who can obliterate the target with a single precision-guided bunker-busting bomb. *Twelve O'Clock High* and its armadas of heavies is gone forever.

The U-2's adaptability has spurred the creative drive of two generations of engineers. Although Johnson conceived the CL-282 to look and listen, successive versions have been put to other uses, at least experimentally, a flexibility that undoubtedly pleased him. (He died in 1990.) Two were fitted with air samplers to monitor nuclear tests. Ten were given inflight refueling capability (no longer used). Someone even proposed modifying a U-2 into a bomber, with tricycle landing gear, but the idea didn't fly. Three got folding outer wings for use on carriers. All U-2s now have wings that fold 70 inches from their tips to help get them into small hangars overseas.

Two changes were of fundamental long-term importance: The airplane was stretched and its wing lengthened to extend its range and provide more room for sensors. And the aircraft was converted from analog to digital wiring and electronics, which allowed it to carry a wider range of standardized sensors that can simply plug into the airplane's data bus like computers in a network. The resulting U-2Rs and the TR-1s, both of which had 103-foot wingspans, were 23 feet longer than the U-2 they replaced.

AKAs: The Dragon Lady's Aliases

There is no structural difference between the U-2R and the TR-1, and the two designations are confusing. The U-2R, which first flew in 1967, was a strategic intelligence collector capable of very long flights. The Strategic Air Command used it to locate Soviet uranium enrichment plants, air bases, and naval bases, monitor a French nuclear test in the South Pacific, sniff the air for trace gases from nuclear weapons, and photograph the Israeli reactor at Dimona.

If NATO and Warsaw Pact armies had slugged it out, the aircraft would have been controlled by army commanders. They would have used it to find enemy forces behind the front lines and report on their numbers, their armament, and their location. That mission would have been tactical; hence the "TR" in TR-1 stood for tactical reconnaissance. As it was, TR-1s flew missions along the Iron Curtain until the cold war ended. But the strategic and tactical versions were essentially the same airplane.

Making a distinction in designations also had a political purpose. After the downing of Powers and the revelation of the Central Intelligence Agency's overflights, the United Kingdom and West Germany felt allowing U.S. spyplanes to operate from their territory was embarrassing—or awkward, as the British would have put it. The United States flew regular reconnaissance missions in four-engine RC-135s around the periphery of the Soviet Union, but those aircraft looked like innocuous transports. U-2s, on the other hand, looked the part. Changing the Dragon Lady's designation to TR-1 accommodated our allies' sensitivities. Eventually, juggling two separate sets of manuals and maintenance records that were essentially identical became a burden, and there was funding confusion, so in 1992, with the cold war at an end, the TR-1s were quietly rechristened U–2Rs, and the TR-1 was history.

Life Support: Flying in Rarefied Air

Like the U-2s themselves, pressure suits have steadily evolved. Francis Gary Powers' suit was primitive compared to Rob "Skid" Rowe's custom-fitted, $250,000, 1034-type suit. Rowe is the Skunk Works chief U-2 pilot, and he likes to say that he wears his cockpit, which is a self-contained environment that weighs 35 pounds. In the event of rapid decompression at high altitude, the suit would instantly fill with air to keep the nitrogen in his blood from forming bubbles and bringing on the painful bends. The suit is made of Nomex, a DuPont-developed fabric that is both tough and flame retardant. And whereas Powers' suit was olive green to help him evade the enemy if he bailed out, the 1034 and others like it are yellow or orange for the opposite reason: to enhance a pilot's visibility to rescue crews. There are 249 model 1034 pressure suits in the world, Rowe says, and they are used by about 90 pilots. The suits are so carefully integrated with the airplane that the switches on the instrument panel are sized for the suit's thickly-gloved fingers.

Early 1950s pressure suits were a drab green so CIA pilots could hide after bailout. The new suits brighten rescue prospects.

Airman First Class Carol Garlick checks out lunch: Insert tube into mouth through helmet port. Squeeze.Yum...

The helmet, which locks into the suit's round collar, has the standard two visors, one clear and one dark, found on all military helmets. But it also has a quarter-inch hole in it through which the pilot on a long flight can dine by uncapping a toothpaste-size tube of food, screwing it into a five-inch-long plastic cylinder, sticking the cylinder through the hole and into the mouth, and squeezing. The pilot can choose from a wide variety of fruits, vegetables, and meat dishes such as beef stew. Every tube has a light blue sticker that lists its contents, such as "FOOD VARIETY: Peaches." All of them are similar to baby food, which figures, since they are made by Gerber. Unlike the jars at the grocer's though, the tubes cost $3. Orders are taken during suit up, and the food is put in the cockpit by technicians, who yell the menu

The latest reincarnation of the Dragon Lady is the U-2S, which the Air Force began operating last October. There are 32 of them, along with five two-seat training versions, designated U-2ST. The U-2S is the airplane Swords most likes to talk about. He says that over the last decade, more than $1.7 billion has been spent to turn it into a new aircraft. The U-2R's Pratt & Whitney J75-13B engine, for example, was replaced by a General Electric F118-GE-101. The newer engine is 30 percent lighter, 39 inches shorter, more fuel efficient, and much easier to maintain, needing an overhaul every 2,500 hours instead of every 800. Swords says that only 10 percent of the engine was redesigned specifically for the U-2S. The rest is the same as the engines used in the F-16. With the new engine, the S gained 1,220 nautical miles of range and about 3,000 feet of altitude.

The Air Force trains pilots in the U-2ST, with the student in front, instructor in back. The second cockpit takes the space where the huge Q-bay and its cameras and avionics would be, so the trainer can't double as a U-2S on photo missions.

Maximum altitude is a sensitive subject. Lockheed Martin and the Air Force refuse to discuss the U-2S's service ceiling; official statements will only say that it is "above" 70,000 feet. One Internet site has incorrectly stated that it can reach 90,000 feet. Based on its dimensions, an aerospace engineer friend of mine once calculated that it could reach 75,000 feet with full fuel, 78,000 toward the end of a mission.

The new engines, which converted R models into S models, are only a small part of a continuing modernization process that is still driven by the sensors. The ground technicians can mount different noses, which are interchangeable the way lenses on a cam-

to the pilot just before the canopy comes down and seals.

At the other extreme, there is the waste disposal system, which varies according to the gender of the pilot. Women wear a diaper like those used on the space shuttle. (The first female Air Force pilot flew a U-2S in the mid-1990s, and there are now three mission-qualified female pilots in the Ninth Reconnaissance Wing at Beale Air Force Base in California, which operates the aircraft and deploys it around the world. The fifth woman to fly it is waiting to begin training.) Men use a urine collection device, a molded latex tube that is fitted to the pilot and has a clip to close it off at the end. The long tube hangs from an opening in the white cotton underwear that is worn under the pressure suit. "Occasionally," says Mark Mitchell, "various people on tours would like to see a pilot suit up. It was always interesting to walk out of the locker room in your underwear with a long tube hanging out of your crotch."

The pressure suit has a valve on its left leg. The UCD is connected to the valve during suit up, and while the pilot is strapping into the cockpit, a technician takes a clear plastic tube that comes out of the other side of the valve and jams it into a receptacle on the control column that sends the urine into a container under the floor in front of the seat. But the setup doesn't always work, Mitchell says. "There are more than a few pilots who finished the mission with a very wet foot." Before missions, pilots eat high-protein, low-residue meals, such as steak and eggs.

Even the wing tips and the mid-wing "super pods," which look like fuel tanks, are crammed with sensors and electronics. Its paint scheme makes it look stealthy, but a U-2 is detectable by radar.

DENNY LOMBARD/LOCKHEED MARTIN

era are, so one kind of imaging system can quickly be substituted for another: optical for radar, for example. Other sensors, avionics, and navigation equipment are carried in a number of places: in the E-bay in the airplane's upper fuselage, in a larger, fuselage-wide Q-bay behind the pilot that carries cameras pointing downward, in large wing "super pods" that hold signals intelligence equipment, and at the wing tips. A special teardrop-shape pod that sprouts from the upper fuselage, sometimes erroneously thought to be radar, houses an antenna that transmits data via satellite relay.

Wired Eyes

The new intelligence collecting devices are not only extraordinarily sensitive, they also interact with one another like components of a nervous system. The sensors either look or listen, and three of them collect imagery:

An ASARS-2A (for Advanced Synthetic Aperture Radar System) is nose-mounted for all-weather and day-night capability. It can observe 100,000 square miles of Earth's surface in an hour with a resolution of one foot. The radar has a moving-target indicator that can highlight a column of advancing tanks, for example. The 2A is the latest version of the ASARS and is just going into operation.

An electro-optical system called SYERS 2 (Senior Year Electro-optical Reconnaissance System) uses five visual and two infrared bands that can combine to penetrate haze or darkness. It too is nose-mounted and continually upgraded to improve collection at night and bad weather. The infrared system is so sensitive it can detect the temperature difference between the cooler fuel in an airplane's tanks and the warm airframe and show the amount of fuel on board.

A wet film system, called an Optical Bar Camera, that was initially developed for the Lockheed SR-71 Blackbird has been converted by Goodrich to be carried in the U-2S's Q-bay. Its 66-inch focal length produces very-high-resolution photographs straight down and at angles to the sides of the airplane. Though it still uses film, the camera has been improved. And although the images on the film can't be transmitted until the film is developed after the airplane lands, wet film produces photographs that are clearer than digital images.

And soon there will be more eyes: Hughes is developing a compact, lightweight, electro-optical infrared sensor called the DB-110 that will collect high-resolution imagery in two bands for any or all of three image types: continuous ground coverage, spot coverage, and stereo 3-D, all three modes distributed via data link.

If one system can be said to represent the future U-2, it is the SPIRITT—the Spectral Infrared Remote Imaging Transition Test—which is being developed by the Air Force Research Laboratory at Wright-Patterson Air Force Base outside Dayton, Ohio. The idea is to create a day-night, high-altitude, super-sensitive sensor test bed that will combine optical images and radar

to get an almost instant, high-quality picture of the target. The system will be so sensitive it can spot even obscured targets, like tanks hiding in thick forests. The foliage-penetrating program even has its own name: TUT, for Targets Under Trees. It will use data from very-high-frequency synthetic aperture radar and other sensors. And the whole integrated package is being designed to fit into the Dragon Lady's Q-bay and into its unmanned counterpart, the Global Hawk. Pat Fillingim, a spokesperson for the Air Force Research Laboratory's Sensors Directorate, which is developing SPIRITT, describes it as potentially "a new sensor suite for an old lady."

At one point, someone also had the idea of using the high flier to photograph satellites. The plan was to extend the nose four feet and put in a camera like those in reconnaissance satellites, using a standard mirror set at a 45-degree angle. The passing satellite's image would reflect off the mirror and into the same kind of long-focal-length parabolic mirror that was used in the KH-9 Hexagon reconnaissance satellite. But it was decided that the elaborate system would cost more than it was worth, so it was killed.

Distant Whispers

Other collectors carried by the U-2S listen. One suite receives both communication traffic and other kinds of electronic emanations, such as radar signals. These signals can be relayed directly to deployable ground stations—DGSs—in the field, or, via satellite relay, anywhere on the globe. No one at Lockheed Martin will say that the relay spacecraft are Defense Satellite Communications System IIIs, several of which are in geostationary orbit 22,300 miles above the equator. In time of war, voice and coded communication can be pulled in by the U-2S and relayed directly to friendly forces.

The signals intelligence systems include Senior Ruby, which monitors radar emissions; Senior Spear, which eavesdrops on communication traffic; and Senior Glass, which gathers signals intelligence and the capabilities of which are still classified. They are carried in the two super pods.

The U-2S also has what Mitchell calls a "superlative" new defensive system. It is the AN/ALQ-221, which listens for threats, displays them, and then automatically employs the appropriate countermeasures, including transmissions that confuse the attacker. All the pilot has to do is turn it on.

The U-2S is equipped to know when it is being tracked on radar and infrared sensors on hostile aircraft or, more likely, surface-to-air missiles. Radar relies on accurate timing, and most countermeasures work to corrupt that timing dependence. The aircraft also have the capability to reduce their heat signatures, as well as systems to defend against an infrared-seeking missile. And the Air Force is experimenting with a communication intercept system that would not only pick up attacking pilots talking to one another but would almost immediately transmit messages to confuse the pilots—in their own voices. It will almost certainly go in the U-2S.

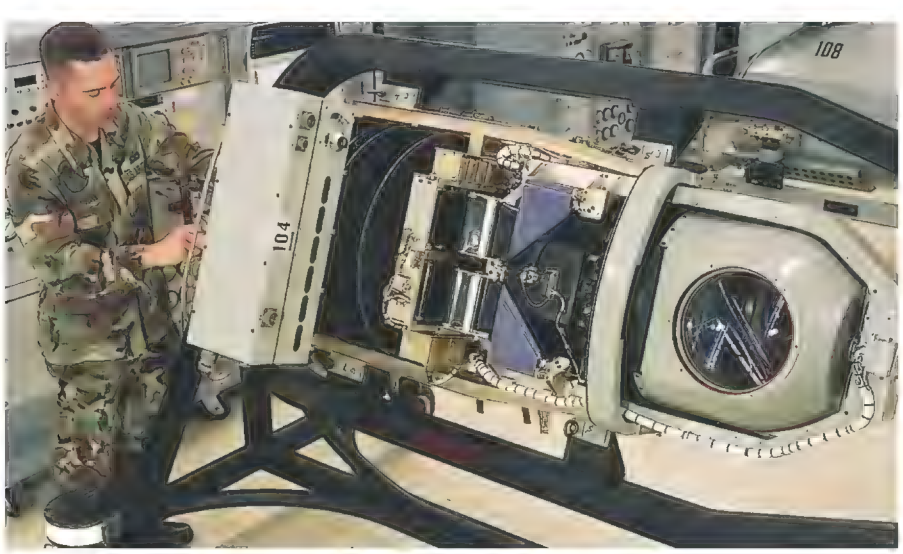
The sensors are interconnected and redundant—they back one another up. For example, the radar and the infrared optics can produce a single image, and instead of all the airplane's avionic systems and sensors running on separate cables and connectors, a data bus similar to the network cable connection for a group of personal computers routes signals to the appropriate sensors. And it can even send them to a backup if the primary one is inoperative.

Background Noise

The close integration of all the electronics makes the U-2S an unprecedented intelligence collector, but so many sensitive electronics can also bite one another in new ways.

Discussion of the U-2S's signals intelligence capabilities—what and how sensitive they are—is carefully guarded by the military. The radio monitoring system has high-frequency, very-high-frequency, and ultra-high-frequency bands that pick up transmissions with an antenna farm that sprouts from the belly of the aircraft. Their sensitivity can be inferred by the fact that as new systems are added the existing ones can interfere with them, and even the wiring that moves data around the aircraft can reduce the quality of what they collect.

Quick-change hardware makes it easy for Airman First Class Timothy Wolfe to remove the smooth SYERS nose and attach the knobby ASARS-2A package being rolled into position on its adjustable cart. The swap is like changing the lens on a camera.



Staff Sergeant Adam Marigliani loads some two miles of film into the Optical Bar Camera, which is based on an earlier SR-71 unit. The big gray-domed lens swivels to shoot straight down and off to both sides, covering thousands of square miles.

Senior Year: The U-2 at 50 is as majestic as ever and good to 70.

"What will a new sensor do to the other systems?" Jim Kaplan, Lockheed's mission systems senior manager, wonders aloud. The wiring that carries electrical power creates enough electromagnetic noise to degrade the intelligence. Some of the systems can interfere with their own mission, but the U-2S is supposed to pick up signals, not listen to its own wheezing.

So with Block 10, the Power/Electro-Magnetic Interference Program, every aircraft is completely rewired with shielded, grounded, low-emission copper, fiber optic, and other cables. And the word "power" means providing enough electrical generators to carry out current missions while having enough in reserve for the future without having to rewire yet again.

The update called Block 20 is the most radical and important. It is formally known as the Reconnaissance Avionics Maintainability Program—RAMP. Less formally, it is called the glass cockpit, and it converts the U-2S cockpit to a current digital standard.

That New-Airplane Smell

Comparing the old instrument panel and the new one shows the difference between the two aircraft vividly. The analog panel was crowded with the two dozen or so little gauges and dials that showed heading, airspeed, altitude, engine performance, turn-and-bank angle, and the rest. There was even a telescope that showed the pilot the ground below. Many of the instruments had to be scanned regularly, with the pilot interpreting their readings and performing a lot of mental gyrations to maintain a picture of the airplane's position and attitude in three-dimensional space.

The glass cockpit is dominated by three six- by eight-inch multi-function displays—small TV screens arranged in a compact triangle. These take the same information and combine it into single interactive displays. All three are completely interchangeable. Each can display the route the aircraft is on, its location on that route, and significant geographic features, such as towns and lakes. And they do it in color: Land is tan and water is light blue. Or they can provide a closeup of the terrain below without forcing the pilot to peer through a telescope.

People in the program say that the point is better maintainability, not just improved performance. They also emphasize that common parts are used whenever possible. When it was decided to replace the old optical telescope used to scan the ground below with an electronic eye that would display a similar picture on one of the multi-function displays, a standard commercial Sony camera was modified to withstand the minus-76-degree Fahrenheit temperature at altitude. Use of available equipment is called COTS, for commercial off the shelf.

Other improvements involve the life support systems (see "Life Support: Flying in Rarefied Air," p. 24), which have always been plagued with problems in flights at ultra-high altitudes and lasting hours.

Unmanned aerial vehicles, or UAVs, don't have those problems. UAVs are also the U-2S's implacable rivals. The Global Hawk, one of the newest and largest UAVs, is manufactured by Northrop Grumman's Ryan Aeronautical Center in San Diego (see "Send in the Global Hawk," Dec. 2004/Jan. 2005). Its promoters note that it can fly its long-duration mission without risking a life. Its detractors in the U-2S fraternity note that it cannot think.

It is Lockheed Martin policy not to get into mud-slinging with its rivals and instead to take the safe there's-plenty-of-work-for-everybody stance—what is officially called a "balance" between manned and unmanned systems. But some individuals can't resist discreetly straying across the company line. They quietly explain that the human in the cockpit can override the flight program to take advantage of new target opportunities, evade a sudden, unexpected threat, or cope with an unpredictable flying environment. The point is made by color pictures hanging around the office that show a helmeted head with the caption "The Ultimate Computer."

SPLASH

BY MICHAEL MILSTEIN

A sailor's worst nightmare is a ship with a hole in it. Virgil "Gus" Grissom learned that after his Mercury space capsule splashed into the Atlantic, about 300 miles from Florida's east coast. It was July 21, 1961, and Grissom had just become the second American to be launched into space. Before a hovering Marine helicopter could hook his *Liberty Bell 7*, the hatch prematurely blew open. Saltwater rushed inside, and the capsule began sinking as if weighed down with lead. Grissom desperately scrambled out, but his bulky flightsuit didn't seal around his neck, and he forgot to close a port in the body of the suit. The water flooded his spacesuit and Grissom started sinking.

Helicopter crewmen were just about to jump in after him when Grissom managed to grab a lifeline dropped from another helicopter and struggle into a harness to be hoisted to safety. "He probably couldn't have survived more than a few minutes longer," Robert Thompson says today.

Thompson, then a young NASA engineer who had served in the Navy and would go on to manage the space shuttle program, had been given the job of recovering the first manned capsules and crews that the nation lobbed into space. It was a job that had never existed before, so sometimes he and his co-workers had to learn things the hard way, such as the need to provide the astronauts with life rafts and flotation devices. To carry out the recoveries, the space agency commissioned the U.S. Navy to provide the necessary aircraft, personnel, and ships, with NASA paying the tab.

NASA (2)

While Navy divers looked on, Gordon Cooper (in raft) and Pete Conrad practiced the recovery part of the Gemini V mission. The actual capsule landed 80 miles off target.

Last summer, one of those ships, the carrier USS *Hornet*, now a dockside museum in Alameda, California, held a reunion of all the crew members who had helped pull out the capsules of the Mercury, Gemini, and Apollo missions. Simultaneously commemorating the Navy's role in the capsule recoveries was the publication of the book *Splashdown! NASA and the Navy*, written by radio journalist Don Blair, who had broadcast Apollo 11's return live from the *Hornet*. The book traces the history of the recovery missions that those at the reunion lived through.

The missions deserve the documentation; they were more complex and far-

DOWN

Fishing astronauts out of the ocean was not for the fainthearted.

The Apollo 17 capsule landed southeast of Samoa. Three parachutes was a good sign; at least two had to deploy or the splashdown would be fatal.

NASA

US NAVY

The first rescue: A Marine helicopter retrieved Alan Shepard from the Mercury Freedom 7 *capsule. Right: Soccer-ball-like floats righted the Apollo capsules if they flipped over on landing, as some did.*

ther-reaching than most people knew. Whenever a NASA capsule and its crew hurtled home, the Navy-NASA team turned into a worldwide catcher's mitt to grab them. And the recoveries never failed. Whether astronauts came down short of fuel, off schedule, or off course, the recovery team tracked them down and pulled them out. "These were guys who had to be prepared to go out in the jungle if we put astronauts in the jungle," Thompson says.

In fact, landing the capsules on the ground had been considered. But since it took all the power of the United States' largest rocket to heave just a bare-bones capsule into space, engineers deemed it impossible to add weighty retro-rockets for braking, plus landing gear and controls to enable the capsules to come down on solid ground. Water landings, on the other hand, could be tolerable if parachutes were used to gentle the impact. And water had the advantage of being consistently flat and expansive, compared with the canyons and mountains that make solid ground a gamble. "Being off a half-mile in the ocean isn't that big a deal," Thompson says. "Being off a half-mile on a runway could mean you have a very bad day."

The Soviets, however, did land their spacecraft on land (see "Aiming for Arkalyk," Aug./Sept. 1998). Ocean landings might have been observed by other nations, and the Soviets fiercely guarded the secrecy of their space program. And according to NASA, the Soviet navy didn't have enough ships and crew to deploy globally for ocean recoveries. So the Soviets designed their spacecraft to smack down on open plains. Ground landings were more complicated and risky—one Soviet capsule nearly struck a school, and another, its parachute lines becoming tangled during descent, smashed into the ground, killing the cosmonaut inside.

Which is not to say ocean landings were always smooth sailing. Even the slightest swells caused the capsules to wobble drunkenly, and few astronauts escaped the curse of seasickness. Training for the Gemini missions required the astronauts to spend 18 hours inside a capsule in what NASA called the "post-landing environment"—the ocean—in case rescuers took a while to find them. Jim Lovell, who would go on to command Apollo 13, withstood bobbing in the Gulf of Mexico off Galveston, Texas, by propping himself upside down, with his head under the capsule's instrument panel. That's where the wobbling was least pronounced.

Again, the capsule's weight was a limiting factor: "You can't devote half the weight to make it a good vehicle to float around in," says Thompson. He did commission the Navy to design an inflatable flotation ring that the frogmen could install after landing to cradle capsules and hold them steadier.

Seasickness was behind the NASA strategy of lifting astronauts straight from the capsule and into helicopters: Doctors were anxious to get stethoscopes on the spacefarers before the waves made them queasy. But Thompson could see that the astronauts needed help getting out and ready for hoisting, so he asked the Navy to drop swimmers in the water to assist them. The Navy turned to the divers the world would come to know as "frogmen." The forerunners of today's Navy SEALs, frogmen were members of the Navy's Underwater Demolition Teams, trained in covert diving and other water operations. They were just the level-headed experts NASA needed to usher the astronauts out of their capsules. Teams of frogmen trained with astronauts in swimming pools, practicing maneuvers such as getting a crew out of a capsule that had flipped upside down.

The frogmen were a good match for the adventure-loving astronauts, who often were former Navy men themselves. "I just loved [the frogmen's] discipline and dedication," says Milt Heflin, who went to sea as a lead recovery engineer and is now chief of NASA's flight office in Houston, Texas. During training for Apollo 14, dive team leader Bob Rohrbach and astronaut Alan Shepard agreed that their radios were undependable, so they came up with simple hand gestures to signal to each other through the capsule window. Sure enough, the radios did not work, and the hand signals did.

Diver Denny Bowman jumped from a helicopter to assist the Gemini II crew. The green dye in the water made the capsule easier to locate. Below: NASA developed and tested a paraglider that would permit Gemini astronauts to steer during landing, but it was too expensive and undependable.

NASA

NASA LANGLEY RESEARCH CENTER

Each time a Mercury mission took off, NASA stationed upward of 20 Navy ships, including carriers, destroyers, and minesweepers, at bases in Nigeria, Morocco, the Canary Islands, and elsewhere around the world. And on those backup ships, frogmen waited, ready for an emergency splashdown anywhere along the spacecraft's path. The agency even readied a "ship of opportunity" package to drop to civilian ships that happened near an off-course capsule. It held tools and instructions in various languages that explained how to grab the spacecraft and assist the astronauts.

One astronaut was marooned, briefly. On May 24, 1962, M. Scott Carpenter's Mercury capsule, having made the United States' second Earth-orbiting flight, headed back out of kilter and nearly out of the fuel needed for guidance adjustments. No one knew if he'd make it. He splashed into the Atlantic 250 miles from recovery ships. Military aides at NASA's mission control in Houston anxiously launched airplanes along the capsule's likely path.

Out in the ocean, Carpenter noticed water seeping into the capsule. He climbed out its chimney-like cap, inflated his life raft, and activated a beacon. He remembers the wait as a blessing, because it delayed the debriefings and medical exams astronauts had to endure. When airplanes arrived an hour later, he signaled them with a mirror and waved.

"I was sitting there in the raft and I heard this calm voice say, 'Hi there,' " Carpenter recalls. "And three Navy SEALs had jumped out of one of the airplanes and swam up.... So we talked a little bit and I offered them some of my survival food. They said they weren't hungry."

During the second generation of U.S. spaceflights, the Navy almost lost its role in the space program. Aiming to establish space exploration as a routine enterprise, NASA wanted to cut the millions of dollars it spent on vast recovery fleets for every launch. In addition, Gemini mission manager James Chamberlin wanted to show up the Russians with what he considered a landing more dignified than theirs, one in which astronauts steered home, perhaps for a graceful landing on the ground. NASA came up with a new landing device: a paraglider, essentially a giant kite on an inflatable frame. It had evolved from a proto-hang glider dreamed up by NASA engineer Francis Rogallo of the Langley Research Center in Virginia.

The paraglider was to unfold as the Gemini capsules descended. But it weighed 800 pounds more than a simple parachute, and it wouldn't work unless the spacecraft descended at frightening speeds. Tests ended in catastrophic crashes. And the paraglider defeated its own purposes by running up a bill of some $30 million. Engineers decided to try a simpler form, planning to land the last two Gemini capsules on the ground near Pecos, Texas. The astronauts inside would be able to control the paraglider enough to avoid trees and telephone poles. But NASA, anxious to move on to Apollo and the moon, ended up canceling the missions.

By then, agency engineers had learned how to refine orbits and design precise maneuvers to bring spacecraft in on the figurative dime. The recovery team had been able to reduce the waiting fleet from 20-plus to two or three. Landings got so precise that mission engineer Howard W. "Bill" Tindall wrote to the head of the recovery division: "I've done a lot of joking about the spacecraft hitting the aircraft carrier, but the more I think about it the less I feel it is a joke." The December 27, 1968 splashdown of the Apollo 8 capsule, less than three miles from the USS *Yorktown*, "really strikes me as being too close," he said. Though ships could see on radar where capsules were headed and steam out of the way, on one Apollo mission, a recovery helicopter returned to its carrier with a jettisoned fragment of the spacecraft's parachute lanyard caught on its antenna.

When it came to positioning the ship that would pull the Apollo 11 crew and capsule out of the Pacific, another issue complicated the picture. President Richard Nixon would be on the *Hornet*, waiting to welcome the first men to go to the moon. Determined to keep the leader of the free world safe from any moon microbes that might escape from the spacecraft, recovery strategist and *Hornet* captain Carl J. Seiberlich decided to station the ship miles upwind of the capsule.

The *Hornet* took on about 150 journalists for the capsule return. The captain had heard that on previous missions, fights had broken out among photographers jostling for camera angles, so he held rehearsals in which they agreed on who would stand where. When they couldn't, he made them flip coins. Still, the Navy's patience frayed as the press reported details of power outages and what seemed at the time to be every shudder of the ship.

A day before splashdown, a tropical storm blew in, threatening to foul the landing parachutes as the capsule descended. Seiberlich had to quickly find new landing zones. He proposed three, all within helicopter distance of Wake Island, where the president was waiting. NASA picked one. The agency reprogrammed the capsule's guidance system, and Seiberlich cranked the *Hornet* up for the 200-mile run to the new site. He had taken pains to be ready: For every job, he had at least three of the *Hornet*'s 3,000-plus crew members trained.

Heading up the team of frogmen assigned to retrieve the Apollo 10 and 11 capsules was Clancy Hatleberg, just back from underwater demolition missions in Vietnam. "I thought this was going to be a walk in the park until we got into it," Hatleberg recalls. His recovery teams had practiced over and over off San Diego, plunging into the water with dummy capsules day and night, in calm seas and rough, until they could perform every step, deal with every contingency, perfectly. "We'd eat, sleep, and practice," says Hatleberg. The divers had no time to watch the televised broadcast of the first human being stepping onto the moon.

For NASA, the moments before splashdown were always among the most nerve-racking. The spacecraft's descent through the atmosphere produced hot ionized gas that cut off radio contact between astronauts and the Earthbound engineers advising them. It was the one point where the

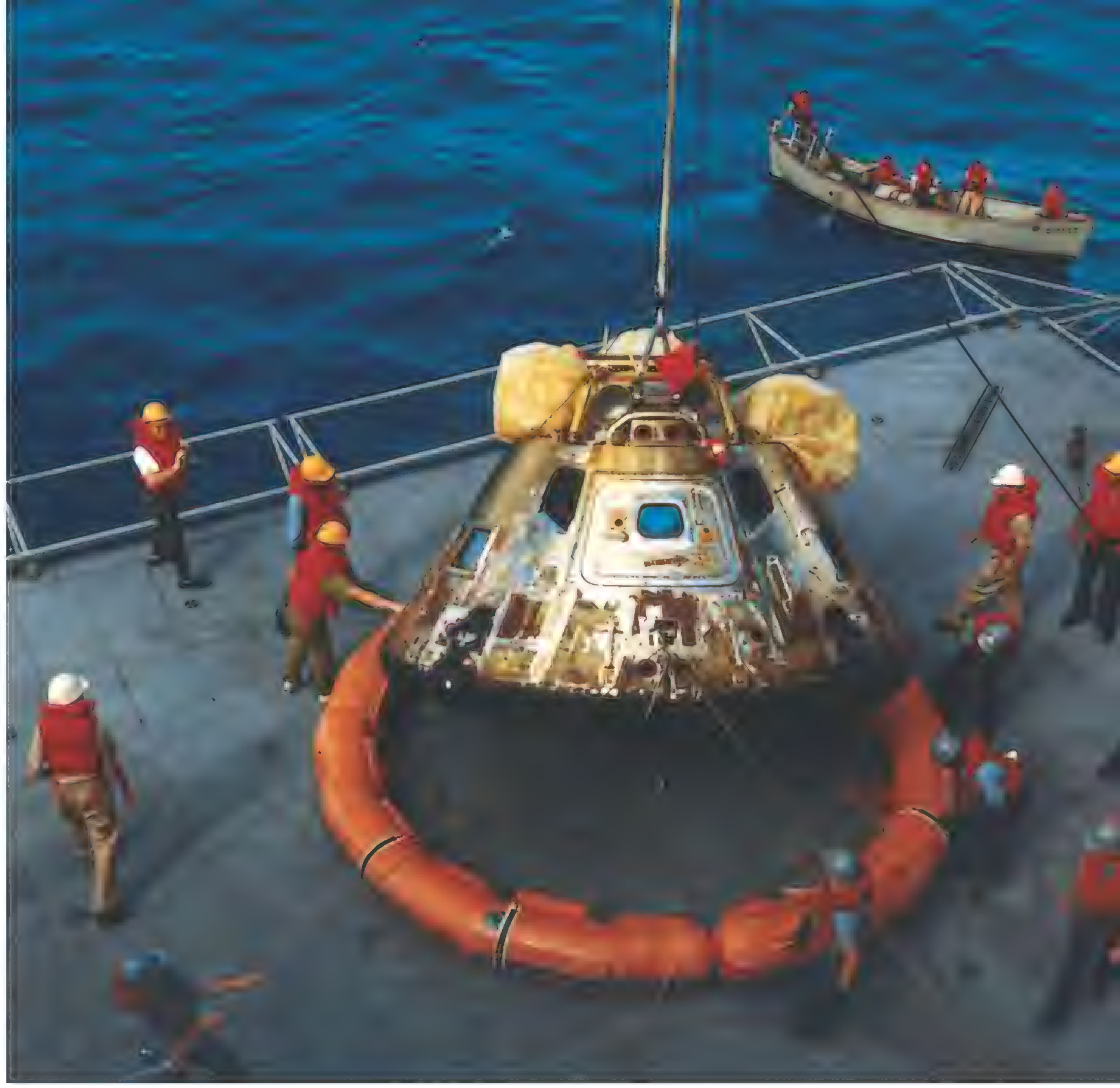
Frogman Bob Rohrbach helped Apollo 14's Edgar Mitchell inflate a troublesome lifejacket (below). Right: The Apollo 11 astronauts on their way to the Hornet*'s quarantine facility. NASA Administrator Thomas Paine and President Nixon watched from what was hoped to be a germ-proof distance (opposite).*

NASA

COURTESY BOB ROHRBACH

Perhaps the most important capsule recovery of all: Apollo 11's Columbia *held the first haul of moonrocks.*

NASA (2)



men in the capsule were entirely on their own.

On the *Hornet*'s bridge, the crew members watched the capsule descend. "It looked like a rivet coming out of the sky," Seiberlich says.

At 7:50 a.m. Hawaii time, the capsule splashed down. Helicopters and their crews of frogmen swept in, racing to be the first ones there.

Bobbing in the waves, the capsule held the three crew members, 48 pounds of lunar rocks, and the attention of the world. Millions watched on television. Helicopters circled overhead.

And Hatleberg worried the astronauts would throw up.

For one thing, the puny barf bags he carried would never prove adequate. More importantly, he had to get the astronauts into isolation suits, and if they threw up after that, which seemed probable in the storm-driven swells, they would have to tear off the fouled suits. That break in quarantine could trigger a series of backup plans that might include quarantining the entire *Hornet*, including the president, for three weeks.

As quickly as he could, Hatleberg opened the hatch, threw in the isolation suits, and slammed the hatch shut. Once the astronauts had put on the suits, he reopened the hatch and helped them from the capsule. After wiping the suits down with the antiseptic Betadine, he helped the astronauts into a raft. Luckily, no one vomited. The astronauts climbed into rope baskets, which were lifted up to a helicopter.

Frogmen waited with the capsule until the *Hornet* pulled up to hoist it aboard, by which time someone (no one admits who) had written "Just married" on the flotation collar.

When the helicopter landed on the *Hornet*, Nixon headed down to greet the astronauts, but Seiberlich stopped him: "I said, 'Sir, if you do that and you get contaminated with moon germs, I'm going to be in a world of trouble.' " Nixon stayed put until the astronauts were inside an isolation chamber made from a gleaming Airstream trailer (it's now on exhibit at the National Air and Space Museum's Steven F. Udvar-Hazy Center in Virginia).

But another cause for worry remained: the astronauts' cache of lunar rocks. Seiberlich had considered the value of that haul when he chose the 19-year-old petty officer who would lift the Apollo 11 capsule out of the rough sea with a shipboard crane. "I picked him because he was pretty steady all the way around," Seiberlich says. "He could have ripped the top off the capsule and it could have sunk. How about that? We get to the end of it and it's all down to the guy running the crane."

Once the capsule was aboard and the rocks removed, the plan was to load the specimens onto an aircraft, which would then be launched from the *Hornet* on a flight to Pearl Harbor, 800 miles away. But Seiberlich had seen carrier catapults fail, tossing aircraft into the water, so he decided to split the moonrocks between two Grumman C1-A Traders. "The joke was: 'There's plenty of astronauts, but there's only one load of moonrocks,' " he says.

Having carried out what may have been the U.S. Navy's most prominent non-combat mission, some of the frogmen who had participated in the Apollo 11 rescue went back to Vietnam. Seiberlich's next job involved devising strategies to defend carriers against nuclear submarines. And NASA moved on to its next mission and its next splashdown.

Apollo 12's Alan Bean, picked up by the carrier four months later, recalled the experience at last summer's reunion: "I looked out the right-hand window and I could see the *Hornet* coming," he said. He was mesmerized by the rolling ocean. "We hadn't seen anything move in the 10 days since we left. Ever since that day, I've loved the Earth."

Resto

Pony Power | Temco TT-1 Pinto

As piston engine fighters were replaced by jets after World War II, the U.S. military began considering how best to train pilots to fly the radically new aircraft. Should prospective fighter pilots learn to fly in prop-driven primary trainers, then move on to jets for basic training, or should they start out in jets? In 1952, the Air Force decided on an all-jet program, and the winner of the ensuing design competition was the Cessna T-37, a twin-engine, bubble-canopy aircraft; the loser was the TT-1 Pinto, manufactured by Temco (for Texas Engineering and Manufacturing Company).

VOUGHT VIA HARRY KENT

But did the Air Force make the right choice? With its uncomplicated design and single engine, the Pinto offered a lot of bang for the buck. Small, nimble, easily maintained, and—most importantly—cheap, the Pinto was the archetypical jet trainer. But it lacked three things: Congressional backing, a champion in the military, and a powerful enough engine. Temco had designed the engine bay and mounts for an engine such as the 2,850-pound-thrust General Electric J85/CJ610, but the only engine available at the time was the anemic 920-pound-thrust Continental J69-T-9. After building a single private-venture prototype, Temco managed to sell 14 TT-1s to the Navy, which used them to see if the service could start its pilots out in jets as the Air Force had.

"Jet envy," says Texas businessman Lewis Shaw, who as an Air Force instructor pilot used both the Cessna T-37 primary and the Northrop T-38 advanced trainers. Shaw owns what is arguably the finest flightworthy example of a TT-1. "The Navy wanted some of what the Air Force had, but all-jet training takes a lot of money, and it didn't fit the Navy's pocketbook," he says. Also, many in the Navy believed it was safer to stay with the better known and, at that time, more reliable piston engines for primary training. Eventually the service chose as its first jet trainer Lockheed's F-80C, designating it the TO-1 and, later, the TV-1.

With over 1,000 hours of instructor experience in his logbook, Shaw is a good judge of an aircraft's suitability as a trainer, and he says the Air Force made the right decision. "The T-37's big advantage is side-by-side seating," he says. "It's a very good training environment because [the instructor] can observe the student." He also agrees with the Navy's assessment that the TT-1 was underpowered; he upgraded his model with the GE J85. But Shaw says the TT-1 is nonetheless an estimable trainer—and a lot of fun to fly.

"Unlike so many ex-military jet trainers, this is an affordable, flyable, and almost practical airplane," he says. "You don't need a ladder to get into it. There's no putzing around. You just get in and go.

"It's mechanical, as opposed to power-boosted," he continues. "The con-

The first TT-1 flew over Dallas in 1956 (above). The 11th arrived at Ezell Aviation in 1998 (below) and got a new instrument panel with modern avionics (right).


JAY MILLER


COURTESY EZELL AVIATION INC.

r a t i o n

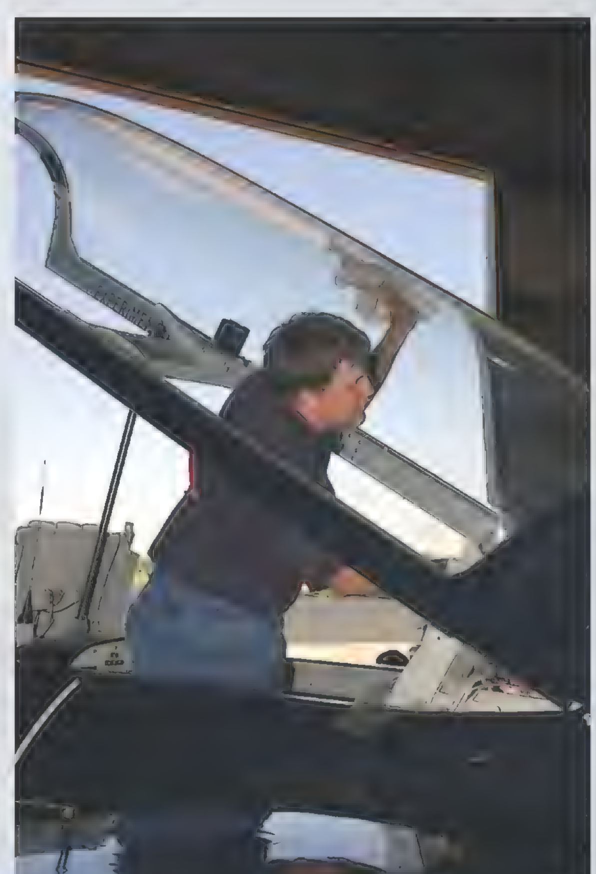
trols are smooth, easily coordinated, and trouble-free."

Shaw's Pinto was brought back to airworthiness by Nelson Ezell and his son Ashley of Ezell Aviation, Inc., in Breckenridge, Texas. What came into the Ezell shop was a fuselage, a tail assembly, some wing parts, and odds and ends—all that remained of an aircraft that for many years had served as playground equipment in a Phoenix, Arizona park. What came out was a brand-new beauty in U.S. Navy-style dark blue paint with 7,000 feet of new wiring, a redesigned wing and vertical tail, modern avionics, and new hydraulic brakes and landing gear systems. So extensively was the aircraft rebuilt that it was registered not as a TT-1 but in the experimental category as an EJ-1, for Ezell Jet 1.

To give the aircraft more directional stability, Shaw requested that Ashley Ezell increase the area of the vertical stabilizer. Ezell also re-engineered the wings, because Shaw wanted internally mounted fuel tanks. "Designing a wet wing was a challenge, but the original aircraft was fuel-limited, not something you want in a jet," says Ezell.

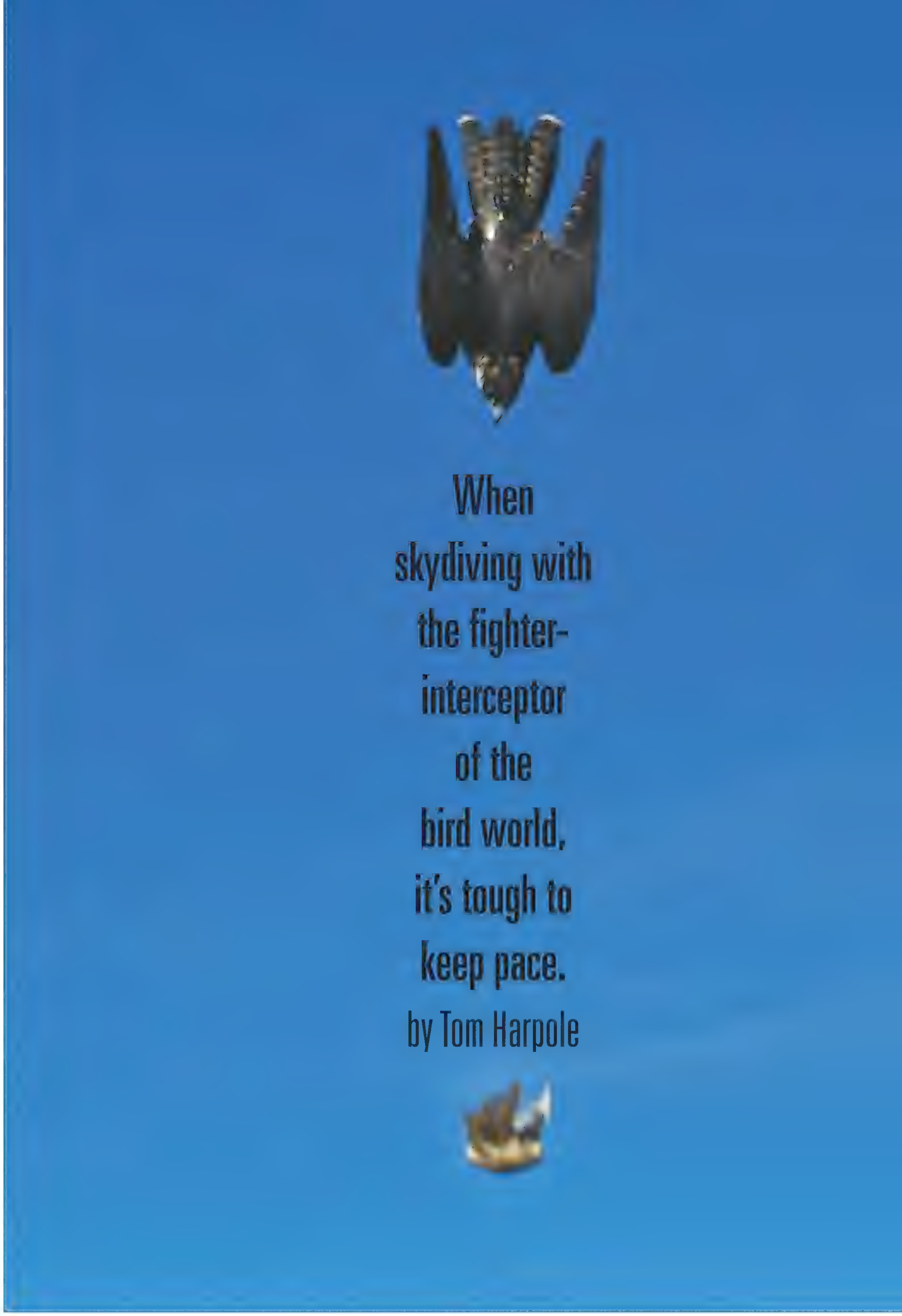
Had Temco gotten the engine it had wanted in the 1950s, U.S. military flight training might have followed a different path—or at least used a different trainer. Like Shaw, the late Allen Paulson of American Jet Industries, one of the first to buy the TT-1 when it became available to civilians in the 1960s, installed a more powerful GE J85 engine in the Pinto's engine bay. AJI also bumped the fuel capacity from 124 to 196 gallons. In this much-modified configuration—unofficially referred to as the Super Pinto by AJI and its partner, Aeronca—the aircraft cruised at 400 mph and its rate of climb jumped from less than 2,000 to 10,000 feet per minute. In fact, the most historically significant moment in the TT-1's career occurred not during its service with the Navy but during a 1972 National Championship Air Races event in Reno, Nevada, when AJI test pilot Dick Hunt flew a triple Immelmann maneuver shortly after takeoff that racing fans are still talking about. What a recruiting attraction that would have been.

—Jay Miller



Smoke streams from Sanders generators on the renewed Pinto's wings. Above: Ashley Ezell and backseater Steve Dickey cruise over a Texas lake. Ezell (right) expended a lot of elbow grease restoring the aircraft, a project that took three years.

JAY MILLER (3)



When skydiving with the fighter-interceptor of the bird world, it's tough to keep pace.

by Tom Harpole

She perches on a bald Cessna tire in Ken and Suzanne Franklin's country kitchen. Frightful, a six-year-old peregrine falcon, is just being herself, loudly cacking and occasionally opening her wings to their full 41-inch span. She flaps her wings and stretches a little, then preens herself with her hooked beak.

Sixteen inches long and weighing 2.2 pounds, she catches other birds, up to the size of ducks, in midair for a living. She ignores a savory piece of barbecued chicken, even though it's within easy reach.

Frightful is a world-class athlete whose directly recorded speed beats that of any other animal ever measured. Cheetahs, sailfish, and black cutworm moths all top out at about 70 mph. When Frightful is stooping—diving after prey—from nearly three miles up, she has been clocked at 242 mph, and it's possible she can go faster.

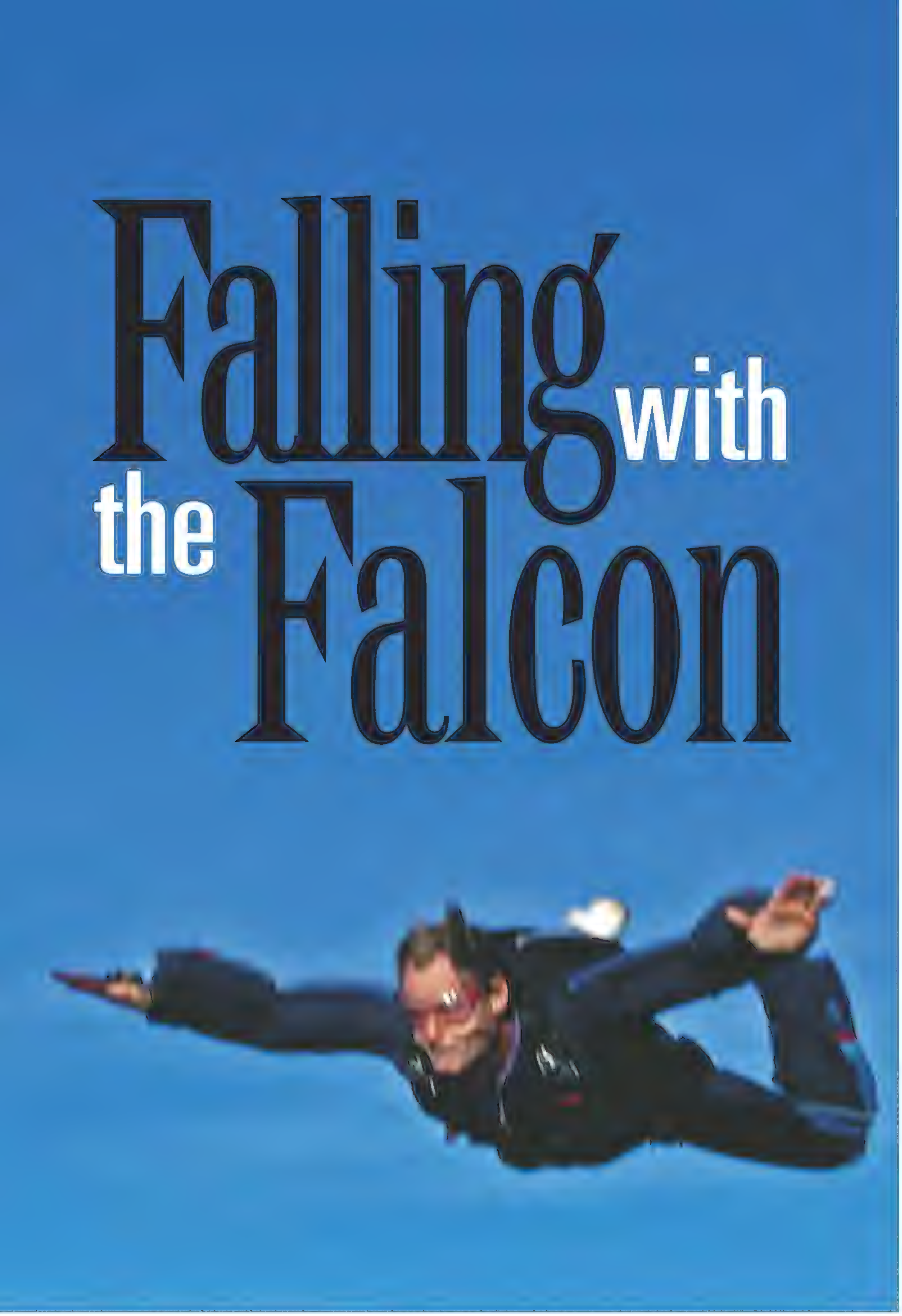
Until recently, estimates of peregrines' velocity varied wildly, from 70 to 300 mph. No one had ever measured exactly how fast the birds can fly until Ken Franklin started stooping with Frightful, or, more to the point, Frightful learned to skydive with Ken.

"Studying falcons from the ground is like studying sharks from a boat," Franklin says. Yet entering any predator's realm, even just to observe, entails certain risks—Frightful's sharp talons and bill are, of course, designed to hold and tear flesh. That didn't discourage Franklin, his wife Suzanne, his father Roy Franklin (a World War II Navy Corsair pilot), several other falconers, two film crews, and Norman Kent, a world-renowned skydiving videographer, from their plan to study a speeding falcon at arm's length—literally. To understand how a two-pound bird can achieve higher speeds than most small airplanes, Franklin has done more than 200 skydives, sometimes as many as five a day, with Frightful.

"Birds are the blueprint for aeronautical engineering," says Franklin, a 46-year-old pilot and master falconer from Friday Harbor, Washington. Orville Wright would have agreed. In 1941 he wrote, "Learning the secret of flight from a bird was a good deal like learning the secret of magic from a magician. After you know what to look for, you see things that you did not notice when you did not know exactly what to look for."

Franklin first took the controls of an airplane at age nine, and now, as a pilot for Federal Express, he would like to see the knowledge he has gained skydiving with Frightful and other fast-flying birds applied to mechanized flight. "Can human flight benefit from these observations?" he asks.

Falling with the Falcon



NORMAN KENT

A bird, a man, a lure. Frightful and Ken Franklin fall at 120 mph, and they're just getting warmed up.

"What remains to be learned?"

To capture their unique data, Franklin and a few mathematicians and engineers devised an elaborate method of clocking falcons in mid-dive. They stripped down a skydiver's Pro-Track recording altimeter/computer, usually worn like a wristwatch, to a computer chip weighing just 0.4 ounce, then fastened it to the underside of Frightful's tail feathers in a way that wouldn't interfere with her flying. During dozens of skydives in 1999, made while the National Geographic film *Terminal Velocity* was being shot, the device recorded Frightful's stooping speeds by measuring how far she fell in a certain time interval.

It's an improbable and wonderful sight to witness Franklin release Frightful into the slipstream of a Cessna 172 at 17,000 feet above sea level. She stabilizes immediately into level flight and matches the speed of the airplane. She flies just off the wingtip, keeping her sharp eye on Franklin, inside the airplane, as he prepares to dive out the door. Then he leaps, and they fall together for more than two miles, along with a lure that Franklin drops during the descent to simulate prey.

Franklin's team verified Frightful's dive velocities with measurements from altimeters worn by videographer Kent and Franklin himself as they plummeted alongside the bird. A fourth altimeter was packed into the lure, and all four altimeters were compared after each jump. The team spent a couple of months working out these techniques and training Frightful, then another seven weeks shooting the film, which aired on the National Geographic Explorer program in 2002 and was nominated for an Emmy award. Frightful also stars in *Birds of Prey*, a yet-to-be-released IMAX film produced by Roy Disney.

But while Franklin and his raptor have caught the attention of the entertainment world, aeronautical engineers and other technical types have largely ignored them. Jim Crowder, a Boeing engineer and leading authority on airflow dynamics who died last year, was one of the few aerospace professionals who paid attention. Crowder lamented the aviation industry's lack of interest in bird flight, particularly peregrine flight. In June 2000, I asked him whether falcons had anything to teach aeronautical engineers. "The easy answer, if talking about Boeing-type aviation, is 'no,' " he replied by e-mail. "Our [Boeing's] position is that aviation is a mature business, and that the discoveries waiting to be identified are probably not worth looking for. Someone would have found them by now."

Crowder thought this corporate indifference, or perhaps arrogance, was misguided. "Personally, I am convinced that birds do all kinds of things that are unknown and potentially worth finding out about," he said. "I have spent my entire career inventing and innovating equipment and testing methods. All too frequently I am asked, 'What good is it?' My usual answer is 'Nothing at all unless you think about it.' "

Franklin has been watching and thinking about falcons for most of his life. At age 12 he captured and began training a red-tail hawk. He'd take the bird

to his father's 66-acre airport adjacent to Friday Harbor (see "The People and Planes of Friday Harbor," Apr./May 2004), where it caught rabbits and small rodents. Falconry became a lifelong avocation, and eventually Franklin sought a way to combine it with his career in aviation. Then he got Frightful from a falcon breeder in Spokane, and knew he had the bird he'd been dreaming about.

On the ground, Franklin looks like Sam Shepard on a bad hair day, as though all those skydives have permanently startled him. He roams his 14-acre farm like a raptor. Shoulders still and head thrust forward, he looks like he's hunting up a meal. In the sky, he is nearly as comfortable as Frightful. At 21, he was the youngest pilot then working for a U.S. commercial airline. He has logged more than 17,000 hours in the cockpits of just about every type of civilian aircraft currently flying, including 747s and MD-11s for Flying Tiger Airlines and FedEx. Arrayed around his farmhouse and sheds are two Cessnas, a Robinson R22 helicopter, and two ultralights, along with the parachutes he uses when diving alongside Frightful.

"Frightful got her name because she is the closest thing to a wild falcon that I've ever trained," Franklin says, yet within two days of hatching she was swept in to the center of the family, to the point where she sometimes acts as if Ken and Suzanne's king-size bed is her nest, preferring to sleep there instead of in her aviary. She often spends hours perched on a ledge above the kitchen counter. She also can be raucous, cacking and flapping her wings when stimulated or displeased, as when a visitor steps out suddenly from behind her.

The secret to a falcon's speed may be in the feathers.

Frightful became "imprinted," or bonded, to Franklin through an incremental training regime, which he devised with Suzanne. The training eventually led to side-by-side skydives. Suzanne, who retains the physique and pluck of a collegiate swimmer, is also a master falconer and ornithologist. She would hold the hooded bird while Ken started flying low and slow in an ultralight over the grass landing strip on his property. When Ken, carrying a lure with fresh quail meat, passed by in the ultralight, Suzanne would pull off the hood and release the falcon. Frightful unhesitatingly chased the ultralight in pursuit of the lure. From there it was a natural progression for Ken to take Frightful up in his Cessna, with his father Roy at the controls.

An important effect of Frightful's imprinting is that she regards Ken, in effect, as her mate. "Training techniques are all about feeding and breeding," Franklin says. Frightful flies along with him on training jumps because she is following her instinct to fly with a mate, especially in pursuit of food.

Her trust in the Franklins is obvious in the easy, comfortable way they are able to handle her. When I warily offer my gloved fist as a perch, she becomes agitated. "Tilt your wrist a few degrees, until you feel her settle," Suzanne instructs. "Feel her."

A "haggard," or mature falcon, Frightful has stiff, unyielding feathers. She is roughly the size of a loaf of bread, and with her wings tucked away and her feathers lying flat against her body, she feels as firm as a football. "Every feather on her body has a saw-toothed, jagged edge that tapers into nothingness," Franklin points out. She can flex her feathers individually or in groups, an ability that lets her make tiny corrections at high velocity. Frightful flies with agility at almost any attitude. Occasionally she flips over in the middle of a 150 mph vertical dive and awaits her prey in midair as it helplessly falls into her talons, unable to pull out of its own dive so quickly or adeptly.

When Franklin and Frightful began freefalling together, they dropped at roughly 1,000 feet every six seconds, equivalent to about 120 mph. For a human in a skintight jumpsuit, spread-eagled with a parachute strapped on, that is terminal velocity—a natural speed limit that a falling object reaches when aerodynamic drag balances the acceleration due to gravity. During their first few dozen freefalls, Frightful learned to stoop at exactly Franklin's terminal velocity. "She was [regulating] her speed to match mine," Franklin

NORMAN KENT

Ken and Suzanne Franklin treat their falcon as more than just a test subject or the star performer that she is. At home she's like a member of the family.

recalls. Then Franklin began releasing lures that could fall faster, at about 195 mph. Frightful tucked into increasingly more streamlined shapes and caught up with the lures, no problem. So Franklin tried increasing his own speed, pulling in his arms and legs as experienced skydivers do. The falcon kept pace with her "mate," and soon they were falling together at more than 240 mph. At that speed they can cover 100 yards faster than you can say "football field."

Franklin describes Frightful's configuration when going into "hyper drive" as asymmetric; she deforms her shoulders the way a person would when trying to squeeze through a very small opening. "She's slipping through molecules," he says; "the asymmetry seems to be part of that." He holds no hope that airplanes could imitate the malleability and asymmetry of a diving falcon. But his years of study and observation of falcons all over the world lead him to suggest that copying certain aspects of peregrine flight could improve aircraft efficiency.

"Studying falcons from the ground is like studying sharks from a boat," says Franklin.

John Szabo, an articulate and agreeable theoretical mathematician in Cheney, Washington, is a master falconer who collaborates closely with the Franklins. Szabo has calculated that when the two-pound Frightful pulls out of a high-speed dive clutching her nearly two-pound lure, she undergoes 27 Gs of deceleration: At that moment, she and her prize weigh slightly more than 100 pounds. Based on Szabo's mathematical modeling and Franklin's measurements of Frightful in mid-dive, the two men think the secret to a falcon's speed may be in the jagged edges of its feathers, which mitigate the effects of air turbulence and make the bird more streamlined. The jagged edges disrupt the airflow less than squared-off edges would. "Look at the wake turbulence behind a canoe compared to a rowboat with a square transom," Szabo says.

Szabo, who has done research for NASA in computational fluid dynamics, says that nature is full of these kinds of adaptations for moving through air and water efficiently. In the case of shark skin, for instance, the ribbed texture of the scales helps to reduce drag, a finding that in recent years caught the interest of swimsuit manufacturers. "It wasn't until the 2000 Olympics that the obvious advantage of minuscule dimples in swimsuits could radically improve efficiency over smooth suits by more effectively diffusing turbulence," says Szabo. "Altering the design of swimsuits took a cross-disciplinary approach."

Likewise, a stamped or incised surface that replicates the jaggedness of falcon feather tips, could, he and Franklin suspect, significantly improve an aircraft's efficiency. "Look at how vortex generators have revolutionized aviation," Franklin says. "There's still room for improvement in drag reduction."

MARTIN DOHRN

The jagged edges of a peregrine's feathers, which disrupt airflow during its dives, may be the secret to its high terminal velocity—upward of 240 mph. Aeronautical engineers use basically the same principle to roughen up the wing of an airplane, reducing drag and improving fuel efficiency.

Although they arrived at this conclusion independently from aeronautical engineers, the falconers are hardly alone in suggesting it. Nearly 20 years ago, scientists at 3M developed an adhesive film with a micro-structured texture that, when applied to the surfaces of an aircraft wing, will reduce drag, resulting in greater fuel efficiency. Even a one percent reduction in fuel use for a wide-body jet saves about $100,000 in fuel for each aircraft annually, according to 3M's Web site.

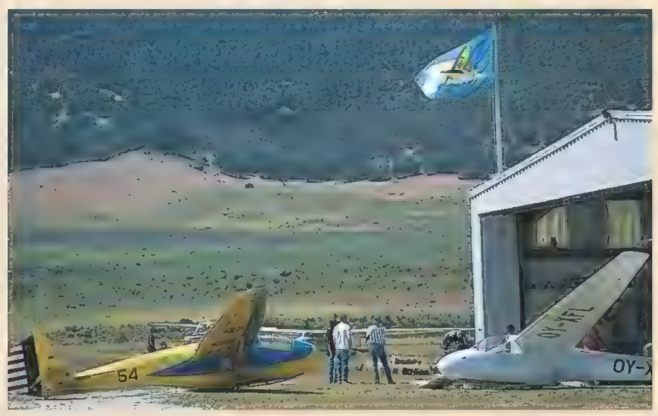
Not everyone agrees that Franklin's research tells us much about the behavior of wild peregrines. Some falcon experts have called his studies artificial, because freefalling from 17,000 feet is unnatural behavior for falcons, who normally stay below 14,000 feet. Franklin says the only reason he goes so high is to get more time for his observations, and that doing so doesn't make much difference to the bird. "Falcons can accelerate from 100 mph to 200-plus mph in eight seconds in pursuit of prey," he says. "They don't need that vertical space to accelerate. But they often ride thermals up to cloud base, getting a free ride up the column of air, checking out everything in the airspace for a meal. They soar at altitude, practically invisible, waiting for prey—then they stoop. To say that stooping from 14,000-plus feet is not normal for a falcon is like observing a Ferrari on a crowded freeway doing 55 mph and assuming that's all they can do."

Ken and Suzanne Franklin would love to see their falcon studies contribute to even modest improvements in aircraft efficiency. And even though aerospace companies are hardly beating their door down, Franklin takes every opportunity to deliver his message. Last September, he addressed a meeting for Boeing engineers and the British Royal Society of Aeronautical Engineers at the Museum of Flight in Seattle, and he regularly talks to groups of pilots and birders.

In the meantime, he and Frightful continue their high-dive act. Looking each other in the eye while falling at 242 mph, they share a knowledge and a bond that few people, let alone people and animals, could ever know.

VINTAGE C~H~A~

Winding north out of Los Angeles, the road to Tehachapi is the nation's unofficial Aerospace Highway, linking some of aviation's holiest technology shrines: Palmdale, birthplace of the B-2 and headquarters for Lockheed's Skunk Works; Mojave, the world's first commercial spaceport, thanks to Burt Rutan's rocketship; and the Mecca of flight testing, Edwards Air Force Base. Doug Fronius, a Northrop Grumman engineer, has been to Edwards many times for flight test events, but today he zips past that exit and bears northwest, toward a mountain pass dotted with wind turbines. He is heading for a tiny, uncontrolled airstrip in Tehachapi. Today, Fronius, who has worked on sophisticated unmanned aerial vehicles like the Global Hawk, is taking a giant aeronautical step backward.



Dashing in color and full of character, vintage sailplanes show up a nondescript modern white counterpart at a vintage meet-and-glide last September (opposite). When weather wouldn't cooperate, pilots hung out and renewed friendships.

On this three-day Labor Day weekend, Mountain Valley Airport is hosting the annual rally of the Vintage Sailplane Association. Throughout the first day, light trucks arrive pulling trailers. About a hundred pilots and owners show up. By sunset, the field is covered with brightly colored aeronautical flivvers that are difficult to recognize and exasperating to spell: Weihes, Schleichers, Schweizers, Slingsby Zanonias, Baby Sedberghs, Dittmar Condors, Meises.

The wide range of manufacturers, designs, markings, and ages distinguishes vintage sailplanes from their modern fiberglass counterparts. "Nowadays they're all painted white, they're all teardrop shaped, they all have enclosed cockpits, and they all have long skinny wings with T-tails," says old-glider enthusiast Jeff Byard. "We call them 'G cubes': Generic German Gliders."

The vintage craft, on the other hand, have been crafted from traditional materials: wood, metal, doped fabric, and glue. "Back then, they didn't have to worry about the sun's effect on fiberglass or composites, so they just finished them to look pretty, either the natural wood or bright colors," Byard observes.

The great variety here today is also due to the Vintage Sailplane Association's relatively liberal definition of "vintage": The group accepts all sailplanes produced through 1958, plus modern replicas of those models. (The European association has a stricter pre-World War II cutoff.) The VSA also accepts both sailplanes, which can stay up on air currents, and gliders, aircraft that simply fly down to a landing. The pilots at the rally use the terms interchangeably.

They're miserable performers and a pain to repair, but old gliders have unbeatable style.

~ *Story and photographs by* Chad Slattery ~

R~M~E~R~S

Most VSA members trace their infatuation with gliders back to the balsa models of their youth. Byard still has his first model, hanging in his Tehachapi hangar: “It’s a Thermic 50-X I made when I was 10. I remember running behind after I launched it and wishing either I could be small, or it could be big, so I could be in it. You’d spend days and days building these things for only a few seconds of flight. You learned a lot of patience.”

Four years later, soaring, and Byard, got a couple of boosts. The first was an article in the January 1967 *National Geographic* in which the writer recounted his experiences with soaring, complete with dramatic photographs and exultations over “airy escalators” and “wheeling hawks.” Just weeks later, on February 19, NBC aired Disney World’s “The Boy Who Flew With Condors,” a story about a teenager soaring above the Tehachapi mountains. “Both of them said that 14-year-olds can learn to fly gliders,” recalls Byard, “so I asked my parents if I could too.” His parents agreed, and he quickly earned his license. (So did plenty of others; the Soaring Society of America added almost 3,500 members that year, and Schweizer Aircraft’s soaring school in Elmira, New York, received over 1,000 letters in just three months.)

Assembling a vintage Schweizer TG-2 took half a dozen men an hour of work. A modern sailplane? Two guys and maybe 10 minutes.

As the pilots at the rally assemble their craft, conversation starts and stops; there are snippets and long discourses on cumulus clouds, someone’s discovery of a rare part, a patching technique. The pace is unhurried.

The assembly of Fronius’ Schweizer TG-2, a design that debuted in 1938, illustrates how much work vintage sailplanes require. “The new ones have just one or two safety pins and take two people maybe 10 minutes to assemble,” says Fronius. “But on the TG-2 there are struts, jury struts, fairings, the vertical fin, the wings, and literally dozens of loose bolts, pins, nuts, and safety pins. You need a crew of three or four people working hard, and it still takes an hour minimum. This was designed for the military, when manpower was not an issue.”

Flying the sailplanes is also inherently social, requiring at least three people: someone to strap the pilot in and hook up the tow rope, a wing runner to sprint alongside the craft at takeoff, holding the wing level, and the tow plane pilot. Slingsby Grasshoppers, one of which Byard owns, were British trainers that were meant to be ground launched, and getting one into the air takes five crew members: a car driver to tow it, a wing runner, a ground observer, a pilot, and a flag man to signal the pilot to release the tow line.

Most in the vintage sailplane community have known one another for years, often having met at Tehachapi. Pilots of both modern and vintage sailplanes are drawn to the airport because of its proximity to California’s Sierra Nevada mountain range, one of the world’s best wave makers. Steady winds sweeping up and over the towering peaks generate ideal conditions for extended soaring; sunlight reflecting off the valley’s angled slopes creates pockets of thermals that pilots can ride like elevators and use to hopscotch over to the Sierras.

Even so, sailplane pilots spend endless stretches of time waiting together in hangars for weather that will sustain

Under a Dittmar Condor, owners shared techniques for restoring their old beauties.

prolonged soaring. "You spend more time talking about flying than flying," says Fronius. "You spend time trailering the glider, assembling it, then cleaning it, and then you might actually fly it, just to prove it can fly. Then you put it away, and then you talk about the flight you had five years ago. And you talk about the record your plane set in 1942. We could have a whole vintage meet and if the wind didn't blow and we couldn't fly, we'd be just about as happy."

Talk at the glide-in turns to the differences between vintage and modern craft. A curious picture emerges. This is an aviation subculture that does not value improvements in performance or engineering breakthroughs or new materials in its aircraft. So what draws these pilots to technologies that are half a century old?

For one thing, they admire designs that are simpler and more artful, even idiosyncratic. And they all cite a love of history. They can recount minutiae about manufacturers, model lineages, design changes, record flights, and, especially, their own airplanes' provenance.

They can also explain the role gliders played in the development of aviation. Designers have long relied on experiences with unpowered airplanes when developing powered versions. The Wright brothers flew gliders for four years before attempting flight in a powered craft. Later experimental aircraft were designed for glider landings, and required glider expertise. Stan Smith, the National Soaring Champion of 1937, served as the chief project engineer for the

A Piper Pawnee tows Doug Fronius and his 1943 Laister-Kauffmann 10A to release altitude, 5,000 feet. (The hat is classic sailplane-pilot: The small brim protects against the sun but doesn't obstruct the view.)

Fronius checks for glider traffic while setting up to land his 1942 Schweizer TG-2.

early-1950s X-2 rocketplane, and when that craft was damaged in early unpowered landings, Smith figured out that shortening the landing skids would make the landings more manageable. Later research aircraft, the M2-F1 lifting body and the X-15, which also landed without engine power, were flight tested under the supervision of soaring altitude champion Paul Bikle.

Vintage-sailplane enthusiasts also take pleasure in the restorations that are inevitably necessary. Virtually every one of the hundred or so airworthy vintage gliders in the United States has been restored by its owner. "You can't just go out and buy a vintage glider," says Byard. "You have to scrounge bits and pieces and then build it up yourself." All during the Tehachapi gathering, underneath a half-century-old Dittmar Condor suspended from the ceiling of Byard's hangar, volunteers lead restoration workshops, and owners teach one another about materials, structures, paints, and finishes—and where to scrounge for parts. The good news: There's no need to learn engines or avionics.

Wayne Spani shares a hangar at Tehachapi with Sam Burton, and between them they own more than a dozen vintage gliders. "Every plane I own, I've rebuilt," Spani says. "Starting with the wings. You'll see old airplanes with intact D tubes [fuselages], but never the wings. They were glued with casein—milk glue—and once that gets wet it's just food for microbes. During World War II, prisoners in German labor camps were forced to build troop gliders, and they'd pee in the glue to sabotage the joints. Building new ones is your safety factor. I guarantee you that if you've found an old wooden glider, you're going to build new wings. You can use pieces from what you have, but you're going to build new wings."

Regardless of age, design, or materials used, all gliders must meet identical safety requirements, and be maintained according to standards set by the Federal Aviation Administration.

Restoring a vintage glider typically takes between 2,000 and 2,500 hours, and the materials can cost up to $3,000. Although prices of gliders are rising through the normal forces of supply and demand, nobody will ever make a profit trafficking in them. Whereas modern composite gliders start at $25,000 for simple designs and top out at $277,000 for Stemme S10VTs with motors for self-launching, vintage Schweizer TG-2s in recent years have gone for around $15,000 if airworthy, $5,000 if non-flying but restorable. Pressed to put a value on his 1947 Schweizer 1-21, one of only two in the world, Walter Cannon guesses $25,000.

One group of old sailplanes, however, prized today for both their aesthetics and their scarcity, fetches premium prices: gull wings—sailplanes with wings bent down slightly at about mid-span. Bob Gaines pegs

Walter and Irene Cannon understandably beam next to their 1947 Schweizer 1-21, one of only two ever built.

the value of his 1935 Kirby Kite at $35,000 and his Kirby Petrel at $50,000. One Minimoa, a 1936 design widely considered the most beautiful glider ever made, was recently bought by Japanese collector Masayuki Honda for, as he told a fellow glider enthusiast, "the price of a nice Mercedes."

Gull wings were developed in response to the discovery that rather than just sailing on the rising wind waves along mountains, pilots would go farther circling tightly on thermals—very compact rising columns of hot air. Famed German designer Alexander Lippisch incorporated gull wings in his 1930 Fafnir glider in hopes of improving visibility and increasing stability in turns. Lippisch theorized that in those turns, the inboard—"gulled"—segment would give proportionately more lift than a conventional straight wing. "It was just one of those intuitive ideas that really sounded great [but] doesn't help that much at all," says Byard.

Another sailplane prized for both rarity and beauty is the Bowlus Baby Albatross. Hawley Bowlus, who had supervised the building of Charles Lindbergh's *The Spirit of St. Louis*, spent hours whittling wooden models to perfect the sailplane's appearance, and weighed every piece of the prototype. An elegant pod made of bent plywood housed the pilot, a handful of instruments, and not much more; a five-inch aluminum tube connected the pod to the tail. The graceful elliptical wings had mahogany leading edges, and translucent fabric that showed the ribs beneath. The Baby Albatross first flew in 1938 and was an immediate hit, a combination of beautiful craftsmanship and, by the day's standards, good handling qualities. In 1940, Don Stevens stunned the gliding world in his Bowlus, doing 83 consecutive loops over

A bicyclist takes in Jeff Byard's Weihe, a German design that dates back to 1938 and kept winning sailplane contests into the 1960s.

Jeff Byard flies his restored Baby Albatross over the Sierra Nevada range, a world-class wave-maker situated near Tehachapi.

Introduced in 1938 as a kitplane, the Baby Albatross had a cockpit with an innovative molded-plywood design. Included were an airspeed indicator, compass, altimeter, variometer, and vertical speed indicator.

California's Kern County Airport, an unofficial sailplane record.

In 1997, after searching for 10 years, Byard bought the 34th Albatross that Bowlus had made. "It was beautiful, and a piece of history, but it flew just terribly," says Byard, noting that it was very unstable in pitch. The Albatross was also fragile. "I wasn't getting much sleep on nights before I flew it," he says. When a rope that was suspending the sailplane for storage slipped and sent it crashing to the hangar floor, Byard decided to completely rebuild it, a process that ultimately used parts from nine Albatrosses. "I improved the pitching problem by moving the all-flying stabilator hinge point forward and going to a larger elevator cable size," Byard says. To shore up the airframe, he strengthened the wing spars with carbon fibers and the struts with steel cables. Unless you have calipers and a set of plans, you would not be able to detect the changes.

That kind of microscopic scrutiny would miss the bigger picture anyway, says Wayne Spani: "People who have never

seen these might go to a museum and find them hanging from a ceiling or sitting on the ground, but you can't appreciate sailplanes until you watch them spiraling upward on thermals, see the sun shining through the fabric wings, hear them whooshing by…."

For the pilot, vintage sailplanes offer a vivid experience that just can't be matched by modern counterparts. Cam Martin has logged extensive hours in both contemporary and old models, including his own classic 1964 Libelle, and he describes the differences this way: "If you hit a really booming thermal in an old plane, you'll hear all kinds of really neat furniture noises; all that wood and doped fabric really talks to you," he says. "The modern gliders have nice manners and don't say anything. In a vintage glider you feel like you're sitting on a hard porch swing. The fiberglass ships have a reclining contoured seat molded to your body—it has more in common with an astronaut's couch than an airplane."

In handling characteristics, Martin says, "they're all from the same family. You push the stick forward and the nose does a predictable thing. But the vintage ones are a little smaller, a little wider, a little draggier. They're not optimized for drag. They tend to have shorter wings, bigger ailerons, more effective rudders. Some people feel they're pitchier—the nose is very responsive up and down, which means you have plenty of elevator. New ones are a little less responsive: the wings are longer and heavier—you tend to want more rudder effectiveness than you have. You always have more wing than rudder."

Vintage glider pilots take pride in eking out victories over "glass" ships during competitions. Fronius recalls a memorable victory he won in September 2003 in his 1943 Laister-Kauffmann LK-10A: "The Dust Devil Dash is a one-day, one-way, free-distance, old-fashioned kind of glider contest. Anyone can enter. Everyone takes off from Tehachapi and goes as far as they can. Wherever they land, they mail a postcard in, saying 'I landed here.' It's a handicapped contest; your miles of distance are multiplied by your glider's handicap. An old, low-performance glider can compete against a modern, high-performance glider fairly, depending on conditions, strategy, and of course good luck.

"There were 19 entries. Most people elected to go north. In reviewing the weather, going north looked difficult for a low-performance glider, and there's a lack of good landing sites in the mountains. So I elected to go southeast, across the open Mojave Desert in the Antelope Valley. I struggled for 75 miles between 1,500 and 2,500 feet in small, weak thermals."

Eventually he was able to cross the valley. "I worked my way into the San Bernardino Mountains and soon to 13,000 feet, ran east almost to Yucca Valley, and arrived at Desert Center at 6,500."

Jeff Byard preflights his Slingsby Grasshopper, a design that debuted in 1952 for service with the Royal Air Force.

From there, Fronius found a series of thermals that ultimately deposited him at Blythe Airport, along the California-Arizona border. The flight had lasted six hours and had covered 235 miles. Three other gliders had gone farther, but once the handicaps were calculated, his had a final score of 388 miles; the next best score, for a sleek ASH-25 made of carbon/aramid-fiber-reinforced plastic, was 351 miles. A 60-year-old wood-and-fabric antique had beaten a 1986 fiberglass world record holder.

On the evening of the third day at Tehachapi, as steaks smoke on the barbeque and the sky darkens, Fronius glances at his TG-2, pauses a second, then confides with a grin: "When you fly an old glider, you can never lose. If you do really well and beat the modern sailplanes, it must be because you're a superior pilot. But if you get shot out of the sky, and land after 10 minutes because you made some really boneheaded mistake, and the glass ships had a great flight—it was only because they had a superior aircraft. It had nothing to do with your piloting."

IN THE DARK

Percent of the universe we can see: 4.

Number of scientists who know what makes up the rest: 0.

W

HEN SCIENTISTS RECEIVE QUACK LETTERS, THEY ARRIVE BEARING CERTAIN CHARACTERISTIC TRADEMARKS. THEY TEND TO BE WRITTEN IN LONGHAND, WITH PENCIL, THE PAGES COVERED WITH SMUDGES, STAINS, AND INSCRUTABLE CABALISTIC SYMBOLS, AS IF THE WRITER WERE ORIGINALLY FROM THE PLANET WEEBO.

by Ed Regis

The author invariably claims to have spotted a hitherto-unnoticed flaw in Einstein's theory of relativity. For the greater good of humanity, he humbly offers to correct it, proposing a melange of previously unknown forces, particles, energy fields, and, commonly enough, flocks of hidden dimensions, which have somehow escaped the attention of generations of scientists.

Today's cosmologists might use computers instead of pencils, but otherwise their latest theories bear a suspicious resemblance to the World Classics of Crackpottery. Consider, for example, a briefing held last May at NASA headquarters in Washington, D.C., broadcast live to NASA centers around the country and Webcast over the Internet. The stage of the James E. Webb Auditorium, tucked away in a glassy, modern building a few blocks from the National Mall, is ablaze with light and crawling with television cameras, monitors, microphones, and crew members, as if this were the 400,000th "Oprah" show. Instead, it's the latest episode of what might be called the Dark Matter/Dark Energy Follies, a series in which a bunch of astrophysicists repeatedly confess that they no longer fathom the universe it is their sworn duty to understand and explain.

"You would think by now scientists would know what the universe is made of," says Andy Fabian of Britain's University of Cambridge. "But we don't."

"This is the most profound problem in all of science," says Michael Turner of the National Science Foundation. The most probable solution, he says with a grin, "is almost too bizarre to be true."

The problem confronting them, however, is simple enough: The expansion of the universe, discovered by Edwin Hubble in 1929, is not slowing down, as astronomers had long thought, but rather speeding up.

The acceleration of the universe's expansion is a minor catastrophe for astrophysics because for the last half-century or so, theorists had been supposing that the mutual gravitational attraction exerted by all the matter in the universe would be sufficient to decelerate, and perhaps halt or even reverse, the expansion. The most recent observations,

BACKGROUND PHOTOGRAPH: DANE PENLAND

however, indicate that just the opposite is happening. The cosmos is flinging itself apart, almost as if gravity no longer exists, or has changed direction, or has been overpowered by some sort of nouveau anti-gravitational, repulsive force.

As if this were a bad horror movie, the force in question has been named "dark energy," a term coined by Michael Turner. Approximately 75 percent of the universe appears to be made of the stuff. "It's the most important thing out there," says Andy Fabian. It is, he thinks, a form of anti-gravity: "It's like throwing an apple into the air and having it accelerate upward."

"Only really weird things have repulsive gravity," says Turner.

To address the problem, astrophysicists have rushed in with a succession of "really weird things" that dark energy could be made of. They've proposed exotic new particles such as axions, accelerons, and, jokingly, "bigons." They've proposed strange new force fields and mysterious forms of energy such as quintessence, k-essence, phantom energy, and negative kinetic energy—whatever that is. And they've proposed various scenarios for the end of the universe at large: a Big Crunch (a grand cosmic collapse) if dark energy weakens, or a Big Rip (where the cosmos is out of here) if it strengthens.

Still, some theorists find all this dark energy conjecturing a bit too much. Georgi Dvali, a physicist at New York University, does not think that dark energy actually exists. In "Out of the Darkness," an article in the February 2004 issue of *Scientific American*, he wrote: "Researchers commonly attribute the acceleration to some mysterious entity called dark energy, but there is little physics to back up those fine words."

Not that Dvali's own solution is any less quirky. The reason that the universe is flinging itself apart, he thinks, is that gravity is leaking out of the cosmos, radiating away, slipping off furtively to somewhere else. Like where? Why, into other dimensions. "The extra dimensions not only sap the strength of gravity," he wrote, "but also force cosmic expansion to accelerate without any need to stipulate the existence of dark energy."

Other dimensions? Well, why not? After all, they've already successfully explained the disappearance of so many things. The other dimension, as we know, is where Jimmy Hoffa ended up, along with Judge Crater, D.B. Cooper (who parachuted out of a Northwest Orient 727 with $200,000), the missing Florida ballots, all that lost airline luggage, and Elvis.

Truly, these are heady days for astrophysicists.

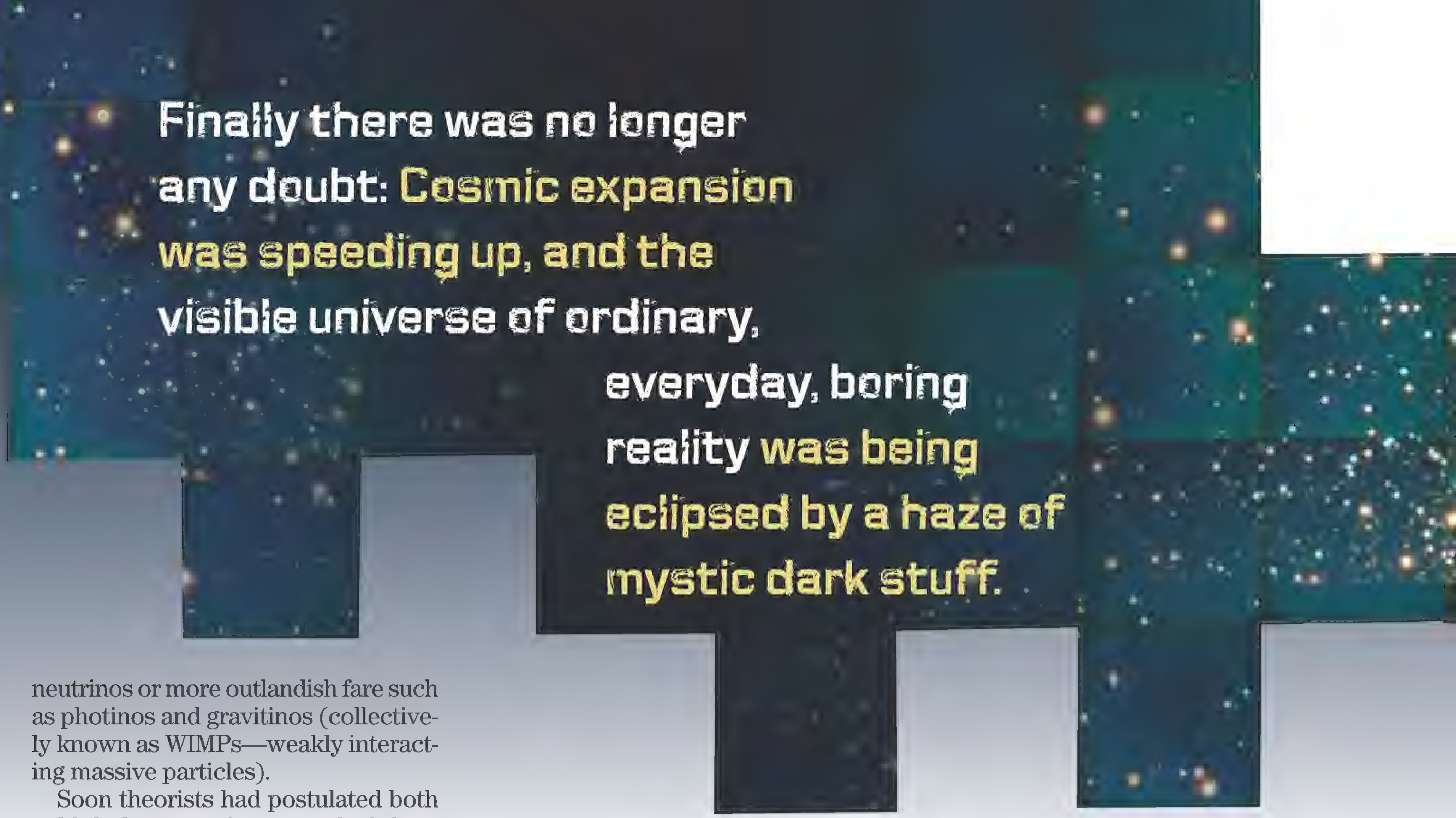
The first clue that the expansion rate of the cosmos was increasing appeared in 1998, when two separate groups of observational astronomers, one working with the Supernova Cosmology Project and the other with the High-z Supernova Search Team, were canvassing the universe for Type 1a supernovas to measure the rate by which cosmic expansion was, as they assumed, slowing down. Type 1a supernovas are stellar explosions of a known magnitude, so they are regarded as "standard candles," celestial bodies whose distance can be gauged by their brightness—the farther the object, the fainter it appears.

The expected slowdown was thought to be a simple function of the pull of gravity. The universe, after all, is full of matter—and not only luminous matter, such as stars. A large part of the universe's mass is thought to be dark matter, a substance whose existence was first postulated in the 1930s by astronomer Fritz Zwicky of Pasadena's California Institute of Technology to explain his observations of galaxies huddling together in large clusters. From what he could tell, the clusters didn't seem to have enough visible matter in them to produce the gravity needed to hold them together. Therefore some unseen mass must be exerting the required gravitational effect.

In the years since, estimating the amount of "missing" mass in a galaxy or galactic cluster became a fairly routine business among astronomers, who at one point were saying that up to 90 percent of the universe consisted of the unlit stuff. The fact that dark matter was an inferred rather than a directly observed phenomenon didn't bother astronomers in the least. Gravity itself is not observed directly, either; its existence is revealed only by its effects.

Astrophysicists had a field day imagining just what dark matter consisted of. In astronomy, "dark" means merely "does not radiate light," a fairly broad category that includes dead or dim stars, unseen planets, black holes, and miscellaneous flying chunks of matter (all of them collectively known as MACHOs—massive compact halo objects), as well as elementary particles such as

With all that dark matter filling the universe like so much invisible turkey stuffing, what could the cosmos do but, sooner or later, yield to its pull and slow its headlong rate of expansion?



Finally there was no longer any doubt: Cosmic expansion was speeding up, and the visible universe of ordinary, everyday, boring reality was being eclipsed by a haze of mystic dark stuff.

neutrinos or more outlandish fare such as photinos and gravitinos (collectively known as WIMPs—weakly interacting massive particles).

Soon theorists had postulated both cold dark matter (composed of slow-moving particles that remained within galaxies) and hot dark matter (particles that had achieved escape velocity and streamed out of galaxies like invisible solar flares). And physicists suggested even wilder theories: Dave Criswell of the California Space Institute proposed that the missing mass was at least partially composed of solar systems enclosed by light-impervious casings built by extraterrestrials.

Anyway, with all that dark matter filling the universe like so much invisible turkey stuffing, what could the cosmos do but, sooner or later, yield to its pull and slow its headlong rate of expansion? And so when in 1998 Adam Riess, a young postdoc at the University of California at Berkeley, and his colleagues in the High-z Supernova Search Team pointed the Hubble Space Telescope toward selected Type 1a supernovas, they had every expectation of finding evidence that the universe's rate of expansion was decreasing. The supernovas in question, however, were fainter than anticipated. Either they were farther away than they were supposed to be or their light was being dimmed by interstellar dust. In the latter case, however, the dust would impart a reddish tint to the starlight, but the light from the supernovas was not red at all. The conclusion seemed inescapable: Counter to all expectation, the expansion of the universe was accelerating.

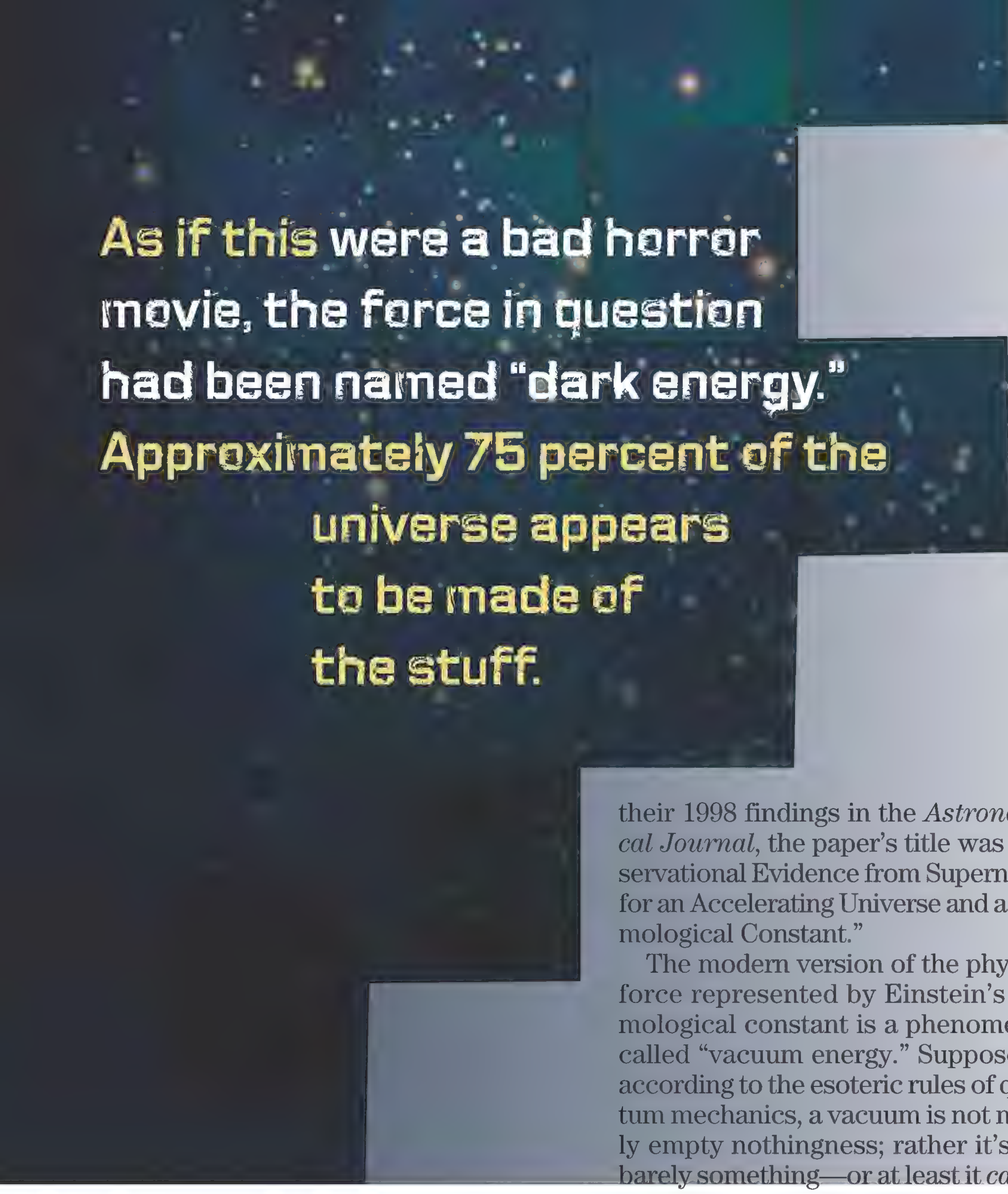
"The most plausible explanation," Riess said later, "is that the light from the supernovas, which exploded billions of years ago, traveled a greater distance than theorists had predicted. And this explanation, in turn, led to the conclusion that the expansion of the universe is actually speeding up, not slowing down." So surprising was this result that, initially, many of the scientists involved were too embarrassed to publish it. What if they were wrong? After repeatedly analyzing their data, however, and seeing no flaw in it, they did, with Riess as the lead author.

Odd as the supernova findings were, they were buttressed within a few years by two other types of observations. The first was a survey of the cosmic microwave background, the distant remnants of the Big Bang. In 2001, data from NASA's Wilkinson Microwave Anisotropy Probe, an observatory orbiting the sun 900 million miles beyond Earth orbit, discovered variations in the temperature of the background radiation; the variations, through a tortuous chain of astrophysical reasoning, also pointed to cosmic acceleration. And then last year, a third study, involving measurements that NASA's Earth-orbiting Chandra X-ray Observatory made of hot gas inside galaxy clusters, confirmed the results of the other two.

The Chandra observations also enabled the scientists to estimate what proportion of the universe consists of what type of substance. The conclusion was that 75 percent of the universe is made up of dark energy, 21 percent is dark matter, and only a scant four percent is ordinary matter—the stuff you can see and touch.

Finally there was no longer any doubt: Cosmic expansion was speeding up, and the visible universe of ordinary, everyday, boring reality was being eclipsed by a haze of mystic dark stuff. The question was: What did it all mean?

When many astronomers heard about invisible forces catapulting the universe hither and yon, the very first thing that popped into their heads was Albert Einstein's so-called cosmological constant. In 1917, when Einstein published a paper on cosmology, the astronomical evidence of the era still suggested a static universe—Hubble's landmark observations of receding galaxies were still a dozen years away. However, Einstein realized that according to both the Newtonian law of universal gravitation and his own theory of general relativity, the universe couldn't be eternally static. Plainly, something had to be done to make his own theory agree with the empirical evidence of the day. And so to make his general relativity equations describe the universe as fixed and unmoving, Einstein introduced a "cosmological term," a sort of mathe-



As if this were a bad horror movie, the force in question had been named "dark energy." Approximately 75 percent of the universe appears to be made of the stuff.

matical fine-tuning of his theory that, lo and behold, yielded a static universe after all.

Today we would regard Einstein's cosmological constant as a fudge factor, a tweak, or, less charitably, a kluge. It was the very image of a gimmick cooked up for no other reason than to "solve" an otherwise intractable problem—and indeed when Einstein learned of Edwin Hubble's discovery that the universe was expanding, he repudiated the cosmological constant, calling it the "biggest blunder" of his life and saying that it was "theoretically unsatisfactory anyway."

But Einstein had regarded the cosmological term as representing an inherent property of empty space—an unknown something that pushed against the pull of gravity—and it was exactly this sort of anti-gravitational force that later astronomers needed in order to explain the newly found acceleration of the universe. And so when Adam Riess and his 21 co-authors published their 1998 findings in the *Astronomical Journal*, the paper's title was "Observational Evidence from Supernovae for an Accelerating Universe and a Cosmological Constant."

The modern version of the physical force represented by Einstein's cosmological constant is a phenomenon called "vacuum energy." Supposedly, according to the esoteric rules of quantum mechanics, a vacuum is not merely empty nothingness; rather it's just barely something—or at least it *can* be something, some of the time. Riess, now at the Space Telescope Science Institute in Baltimore, explains: "The uncertainty principle says that the vacuum can borrow energy from nothing, if it has it for a very short amount of time." This energy—dark energy—exists in the form of virtual particles, which live on borrowed time and borrowed energy. Where do these virtual particles come from and how do they create anti-gravity? "That's the $64,000 question," Riess says. "I mean, really, that is the thing we don't understand. We think it's a property of the vacuum that has to do with quantum mechanics, that even a vacuum still has energy in it.

"But it's not the property of being empty that makes the vacuum have anti-gravity," he adds. "It's actually the existence of virtual particles that we weren't really aware of that's causing the anti-gravity. Apparently, if this is all correct, the vacuum still does have energy in it, in the form of these virtual particles."

Whatever. Vacuum energy is such a strange and unintuitive phenomenon that it has an equally strange and unintuitive consequence: The bigger the vacuum, the more dark energy there is. And so it stands to reason that since the universe is expanding, there should have been a time in the distant past when the vacuum—and hence the amount of dark energy—were smaller than they are now. And in that case, the relative strength of dark *matter* would have been proportionately *greater* than it is now, which means that at some point in the past the universe should have been slowing down after all.

In 2001, Riess found that the Hubble Space Telescope had made repeated images of an extremely distant Type 1a supernova, SN 1997ff, an object that was more than 10 billion years old. It turned out that the object appeared brighter than it would have been if the universe had been expanding at the same rate throughout its history. In other words, the universe had been slowing down way back then, 10 billion years ago. And then it had speeded up.

Later images made by Riess and his colleagues enabled them to determine that the transition occurred some five or six billion years ago. This was the Big Jerk. (Sorry—that's what they call it.) That was when the universe had expanded to a point at which its dark matter had become dilute enough, and its attractive force had therefore become weak enough, for the anti-gravitational push of dark energy to rise up and overpower it. Says Riess: "As the universe moved through time, it slowly removed its foot from the brake pedal until the point when the accelerator became stronger than the brake and started jerking the car forward."

It's an open question where the universe is headed, but the three alternatives are biggies: the Big Lonely, the Big Crunch, and the Big Rip. If the repulsive force of dark energy remains constant, the universe will continue to expand at its present rate. This will make our immediate celestial neighborhood a solitary place, a consequence that the dark energizers refer to as the Big Lonely. If dark energy gets weaker, standard attractive gravity will take over and the universe will collapse in on itself—the Big Crunch.

But if dark energy gets stronger, the current acceleration of the cosmic ex-

pansion will speed up even more. The expansion will feed on itself so that the repulsive force of dark energy will get stronger still, with the physical universe finally rending itself apart in a fabulous bacchanal of disintegration—the Big Rip. Riess describes how it will occur: "Large gravitationally bound systems rip apart, and then progressively smaller bound systems rip apart. A cluster of galaxies rips apart first, then galaxies themselves rip apart, and then solar systems rip apart, then planets rip apart, then nuclei rip apart. It's smaller and more tightly bound systems that will rip apart as there becomes more dark energy in them than binding energy from the ordinary gravity."

Finally, the material universe will be gone. Where to? Don't ask.

All of this was so insane, even to astrophysicists, that there just *had* to be alternatives to dark energy. One of them proved to be that staple of crackpottery, the claim that Einstein's general relativity theory is wrong, that we don't really understand gravity. "Perhaps the most radical idea is that there is no dark energy after all, but rather that Einstein's theory of gravity must be modified," wrote Michael Turner and Andy Riess in "From Slowdown to Speedup," in the February 2004 *Scientific American*.

"Maybe the laws themselves need to be changed," wrote Georgi Dvali, the NYU physicist, in the same issue. They'd changed before, when Newtonian laws were replaced by Einstein's, so why not now? Dvali is a proponent of superstring theory, a complex mathematical effort to present a unified account of nature. One of the cardinal assumptions of string theory is that nature has more dimensions than the ones we're familiar with. "The theory adds six or seven dimensions to the usual three," wrote Dvali. "The extra dimensions are exactly like the three dimensions that we see around us."

The existence of extra dimensions provided the perfect opportunity for Dvali to advance his "leakage scenario," which is his explanation of why the universe's expansion is accelerating. Dvali thinks that normal attractive gravity is leaking out of our universe's three dimensions and into those other ones, causing the universe to accelerate its expansion. His theory has a strange sort of logic to it. Who needs dark energy if you have six or seven extra dimensions as escape routes for gravitons, the particles that, according to quantum field theory, are the carriers of gravitational force? "Real gravitons that leak away are simply lost forever," wrote Dvali. For those of us stuck back at home, "it looks as though they have disappeared into thin air."

Riess, for one, doesn't find the idea so crazy. He compares Dvali's leakage scenario to shining light down a fiber optic cable and getting less light out at the other end than you'd put in. If you lived inside the cable and the cable was your whole universe, then it would appear as if some of the light had simply vanished. "But what's really happening is that light is leaking out a little bit from the cable," Riess says, "and you're missing that."

It's an open question where the universe is headed, but the three alternatives are biggies: the Big Lonely, the Big Crunch, and the Big Rip.

Unconventional as it is, Dvali's theory has the prime advantage of making a scientific prediction that could one day be tested. "I have calculated that graviton leakage would cause the moon's orbit to precess slowly," wrote Dvali. "Every time the moon completed one orbit, its closest approach to Earth would shift by about a trillionth of a degree, or about half a millimeter."

Other experiments to detect, measure, and understand the nature of dark energy are in the works. Saul Perlmutter of the Lawrence Berkeley National Laboratory in California has proposed building a satellite observatory called the Supernova Acceleration Probe to trace the history of the universe through the past few billion years. In 2007, the European Space Agency plans to launch its Planck spacecraft, an observatory that will make yet finer measurements of the cosmic microwave background pattern that constituted one line of evidence for dark matter. And the U.S. Department of Energy and NASA have proposed the sinister-sounding Joint Dark Energy Mission, a space-based telescope dedicated to observing Type 1a supernovas.

Whether any of these observatories will reveal the truth about dark energy remains to be seen. Meanwhile, astrophysicists can only bemoan the predicament of being in the worst scientific fix since the quantum mechanics revolution of the 1920s.

"Dark energy is perhaps the biggest mystery in physics," says Chandra X-ray project leader Steve Allen at the NASA dark energy briefing.

"We don't understand our cosmic destiny," Michael Turner says. "This generation won't solve the problem; the next generation will."

For the time being, anyway, the world's top astrophysicists appear to be in over their heads.

"We're in a situation where we're going to need a new idea," says Robert Kirshner of the Harvard-Smithsonian Center for Astrophysics in Massachusetts. "We're in trouble. It might be our ideas are not wild enough." As if!

It's a typical January day in Chicago—overcast skies, snow on the ground, a high in the 20s—but Terry O'Toole is far more interested in some menacing thunderstorms boiling above the eastern Pacific. O'Toole stares at weather data displayed on a desktop computer screen in United Airlines' flight operations center, near O'Hare International Airport. A dispatcher, O'Toole devises and assigns flight plans, which include routes and altitudes. Like United's passengers and crews—and, perhaps most of all, the company's accountants—O'Toole wants United flights to avoid turbulence as much as possible.

BY WILLIAM TRIPLETT

the Calculators

WHEN FLYING NEAR TURBULENCE, AIRLINES HAVE FOUND

Thunderheads can, of course, be easily seen by both pilots and radar, but not the violent winds that sometimes swirl for miles downwind of a storm. In slightly less than two hours, United flight 52 will depart Honolulu for Los Angeles. O'Toole clicks up a satellite image of the Pacific on his other monitor. A box superimposed on the image warns him of the area in which airliners can expect to encounter turbulence between 28,000 and 38,000 feet. The box lies directly across every possible route O'Toole can assign UAL 52.

Though the storm may dissipate before the flight enters the area, residual turbulence can linger for a long time, causing choppiness. The best O'Toole can do is find an altitude either above or below the "chop." It's the start of a complicated numbers game.

"Rarely do we fly below 28,000 feet," says O'Toole. Ideally, an airliner will climb to a higher altitude, where the air might be smoother. But to minimize fuel consumption, airliners typically fly as high as weight limits allow, so they're already at their ceiling. To escape turbulence, most airliners have to descend; that causes them to burn more fuel, which eats into company profits.

O'Toole clicks on icons of United flights already in the alert area and keys a message to a UAL aircraft flying at 37,000 feet: "How's the ride so far?" He hits the return key, and the message is transmitted via satellite to a computer screen in the airborne jet's cockpit.

As O'Toole waits for a reply, he inputs weather and fuel parameters into a computer that will plot the most economical flight plan for UAL 52, a Boeing 777 that will carry an

# of Calm

THAT WHAT YOU CAN'T SEE COULD COST YOU.

Clouds trace turbulence-creating Kelvin-Helmholtz waves, which form and crash between two air layers with different densities and speeds.

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NCAR

The bumpiest way for the National Center for Atmospheric Research to study turbulence: in its own C-130.

almost-full complement of passengers and cargo. Minutes later a dot-matrix printer cranks out the results: the recommended altitude and route, and a wealth of weather information and figures relevant to other routes and altitudes UAL 52 could be assigned.

"At 33,000 feet, we'll be at five hours and 32 minutes—which is considerably higher than our target time. And it'll require 60,000 pounds of fuel," says O'Toole, looking over the computer's calculations. By contrast, "if I run him at 24,000 feet, we'll be on target time because the tailwinds are so strong there. But you're also looking at burning 8,000 pounds more fuel"—costing about $3,000. "It's nice to make it in less time, but instead of that 8,000 extra pounds of fuel, you could be carrying 8,000 more pounds of cargo or passengers…. But if the air is bad, we go down lower," he assures me. "We don't give it a second thought."

A response comes in from the United flight crew already in the area: "Light chop on and off most of the way; seat belt sign on." According to the printout, if UAL 52 flies at 37,000 feet, it will actually burn slightly more fuel than it would at 33,000 feet, because the tailwinds aren't as strong higher up. But the air seems to be smoother up there. O'Toole decides to take the hit on fuel and schedules UAL 52 for a flight at 37,000 feet. Chances are it's less than the hit—or hits—the airline could take if the flight runs into severe turbulence.

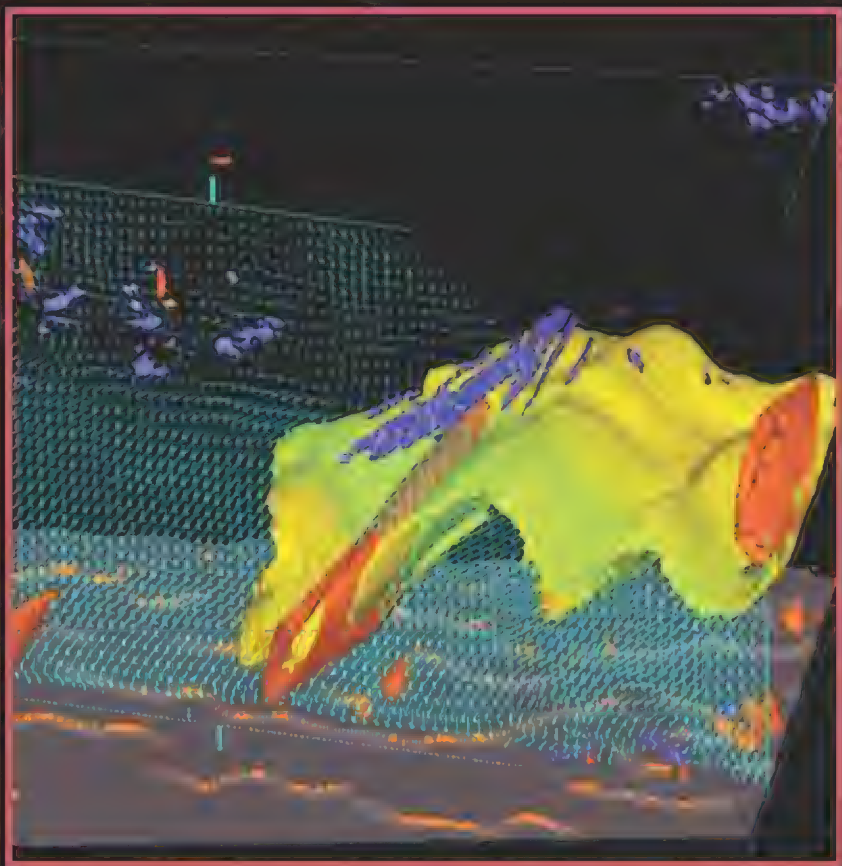
According to statistics compiled by the National Transportation Safety Board, between 1987 and 2000, only two fatal accidents (involving one death each) aboard U.S. commercial airliners were attributed to turbulence, and the phenomenon is believed to have caused the crash of just one U.S. airliner—some 40 years ago—mostly because the pilots failed to respond properly when severe winds struck.

While the majority of encounters with turbulence are not lethal, rough air wreaks havoc on the airline industry. "Probably the least of our worries is that the airplane is going to fall out of the sky," says Lou Andelmo, a dispatcher for U.S. Airways. "It's the injuries we're most worried about." Turbulence is the leading cause of nonfatal passenger and crew injuries, which result in work time losses as well as overtime paid to other crews to fill in. Passenger injuries can also result in lawsuits and settlements. And if a turbulence encounter is severe enough, Federal Aviation Administration rules mandate the airline conduct an immediate, unscheduled (i.e., costly) inspection of the aircraft for damage or stress before the airplane can return to service.

Turbulence can result in so many kinds of financial losses that exact numbers are hard to come by, but the Commercial Aviation Safety Team, a government-industry partnership, has been trying to ascertain and understand costs associated with turbulence as part of an overall mission to study air travel safety. According to Sherry Borener, an analyst at the U.S. Department of Transportation's Volpe Center, CAST found that, among other things, an unscheduled inspection coupled with one day of out-of-service costs totals about $24,000 per incident. A diversion to another airport because of turbulence costs anywhere between $25,000 and $150,000, depending on the airline and the number of passengers affected. Estimates of losses due to delays and cancellations run as high as $866 million a year.

Flight attendants, who spend most of their time on their feet, are most vulnerable to injuries. Northwest Airlines has even produced a training video based on a recent incident in which

A diversion to another airport **because of turbulence costs anywhere between $25,000 and $150,000. Delays and cancellations run as high as $866 million a year.**



A computer simulation of the 1992 atmospheric event over Colorado that damaged a DC-8 uncovered tornado-like horizontal vortex tubes (blue) roiling above mountain wave activity.

one of its flights approached an area of reported severe turbulence: Following a request from the cockpit, passengers and crew were returning to their seats to buckle up when a flight attendant noticed that a door in the galley had an open latch. Behind the door was a rack that could have spilled onto another crew member if the turbulence was rough enough. Just as the attendant stood to lock the latch, a violent downdraft slammed the aircraft; the attendant was knocked to the ceiling, and injured her head and arm.

Candace Kolander, the Association of Flight Attendants' coordinator for air safety, health, and security, says that in 1996, the most recent year for which she has data, in one airline, flight attendants reported 310 turbulence-related injuries, resulting in more than 3,500 lost work days. These are only reported injuries. The CAST study estimates that for every reported injury, more than 15 go unreported; reported injuries alone cost the industry approximately $26 million a year.

And then there are the costs incurred when a passenger sues because of an injury. Darryl Jenkins, a visiting professor at Embry-Riddle Aeronautical University in Prescott, Arizona, who has researched flight-related insurance and litigation issues, says that while airlines will contest some claims, court costs and the chance of bad publicity often force them to settle. In the mid- to late 1990s, he says, "it cost about $30,000 to settle the average claim." CAST's summary of findings states that litigation costs have "dramatically increased," with one recent settlement reaching $10 million.

According to Borener, CAST has estimated that from 1988 to 2001, turbulence cost the industry $31 billion. That number doesn't include costs nearly impossible to calculate: After a bad encounter with turbulence, people who are generally fearful of flying may get on airplanes even less; other passengers, angry that they got no food service while the aircraft was bouncing and lurching, may refuse to fly the airline again. Occasionally, however, the consequences of a rough flight can be known precisely: In 1999, American Airlines shelled out $2 million to a group of 13 passengers who convinced the court that their flight crew's failure to take steps such as lighting the "Fasten seat belt" sign in advance of storm-related turbulence caused "psychological distress," because the passengers thought they were going to die.

NCAR (2)

The DC-8 lost its left outboard engine and 19 feet of wing and fell 500 feet in 10 seconds, but landed safely.

Turbulence comes in two forms: convective and clear air. The first involves updrafts and downdrafts created by hot rising air and cool, moist falling air—both of which you find in and around thunderstorms. Fortunately, moisture reflects on weather radar, making convective turbulence visible and somewhat predictable. Storms can also cause clear air turbulence, but CAT, as meteorologists call it, usually manifests itself in the jet stream—the

west-to-east winds that gust just below the tropopause (the separation between the troposphere—the lower portion of the atmosphere where "weather" happens—and the stratosphere, at roughly 30,000 to 35,000 feet over the continental U.S.). One of the big causes of CAT is the phenomenon known as mountain waves: surface winds that hit mountains and then swirl upward, sometimes for miles, in powerful gusts.

Garry Hinds, manager of United's meteorology department, likens the jet stream to a stream of water. "If the stream is straight and moving quickly, you can get in it and there's really no problem," he says. "But put rocks in that stream, causing white water, and that's what mountain wave is—the atmosphere running into the rocks and getting pummeled and spun—and you get wind shear, which is simply a change in wind speed and direction. That generates breaking waves of air, just like breaking waves of water. The difference between the waves in the atmosphere and the waves in the ocean is you can't see waves in atmosphere." Well, for the most part.

" 'Clear air' is kind of a misnomer," says scientist Larry Cornman of the National Center for Atmospheric Research in Boulder, Colorado. "People use that because pilots fly around and get hit by something they don't see. You can have a mountain wave, which has water vapor that condenses, and so you can actually see the lower part of the wave structure."

Avoiding those waves is one primary job of the dispatcher, who begins working on finding a route even before passengers arrive at the airport. When U.S. Airway's Andelmo starts a shift at the airline's operations center in Pittsburgh, the dispatcher who is about to go off duty briefs him on air traffic control issues, the weather in general, and turbulence in particular. Before planning routes, Andelmo reviews weather information provided over the Internet by the National Weather Service, Weather Services International, and the National Oceanic and Atmospheric Administration (forecasts, turbulence alerts, and pilot reports—"pireps"—can be seen at *adds.aviationweather.gov*).

These sources show thunderstorms and provide the dispatcher with a map of all recent pilot reports of moderate or worse clear-air turbulence. Trouble is, CAT is so mercurial that pireps may be obsolete after only 20 minutes. "Turbulence is like a secondary atmospheric effect," says United meteorologist John Goldman. "You can forecast wind shear, you can forecast atmospheric stability, but it's a combination of those things that causes turbulence, and within an area where there is turbulence, it's not going to be observed at all locations. It's very random."

Indeed, flights often smack into turbulence in areas that pireps had said


NCAR

Next Generation Radar sites, like the Mile High Radar (right) near Denver International Airport, may one day be networked to provide a complete view of turbulence conditions above the U.S.

"Turbulence is like a secondary atmospheric effect. **You can forecast wind shear, you can forecast atmospheric stability, but it's a combination of those things that causes turbulence, and within an area where there is turbulence, it's not going to be observed at all locations. It's very random."**

were smooth. In 2000, a U.S. Airways flight sailing uneventfully over Chattanooga, Tennessee, at 35,000 feet got banged hard by an encounter with turbulence. "People's heads hit the [ceiling] and cracked it," Andelmo says. "We had some serious injuries."

The airlines and the government also work together to prevent rough rides. "We have regular conference calls throughout the day with the FAA and the other airlines where we share any information we have," says United spokesman Jeff Green. "In the case that our dispatchers need to get or share any information, we do have the ability to contact the operations control centers at other airlines."

The airlines and the FAA characterize turbulence as light, moderate, severe, or extreme. Respectively, the categories are defined as (1) causing slight, erratic changes in altitude or attitude and rhythmic bumpiness; (2) same characteristics but greater intensity and rapid bumps and jolts, with passengers straining against seat belts; (3) large, abrupt changes in altitude or attitude and large variations of airspeed, with aircraft temporarily out of control; and (4) violent jolts making control of aircraft nearly impossible and structural damage possible.

But what feels like light turbulence in a 747 might seem severe in a 737. Turbulence even varies along the length of an aircraft: Pilots feel some bouncing, but the center of the aircraft shakes more than the cockpit, and the rear sections sway back and forth more than the center. Says Goldman, "Turbulence is the only meteorological parameter that's a subjective report."

NOAA, in conjunction with the National Weather Service, regularly issues clear-air turbulence forecasts based on calculations of things like temperature, wind speed, and wind direction in different parts of the country and at different altitudes. But some in the industry find the forecasts too conservative. So a few airlines, like United, have invested in their own meteorology departments.

"To put out a CAT forecast that we're confident in is very labor-intensive," Goldman says. "We need to be evaluating a lot of things. Even then, we wait until we start to get verification from flights in the area. And if their reports correspond to what the data are telling us, we then put out a warning." Otherwise United might impose unnecessary deviations, resulting in extra costs. Exactly what those extra costs are is difficult to say, but United's willingness to spend more than $2 million every year just to have a meteorology department is some indication.

Some parts of the country are known for having either convective or clear air turbulence almost all the time, such as above and just east of the Rocky Mountains, particularly around Denver. (United refers to a circle defined by a 50-mile radius around the city and up to 25,000 feet in altitude as "the Denver cylinder," in which pilots can always expect rough rides.) Other usually turbulent areas include the Gulf Coast, southern Florida, the area around Cape Cod, Massachusetts, and the Montana-Canada border.

Along with the National Center for Atmospheric Research and other organizations, NASA's Aviation and Security Program is currently working on what it calls a Turbulence Prediction and Warning System, which is intended to help reduce turbulence-related injuries. According to Jim Watson, the TPAWS project manager, two very promising technologies are being developed to help detect turbulence. The first is a software upgrade of the Doppler radar systems that many airliners already use to detect wind shear. With new algorithms, these radars will be able to look for and process weak radar reflections of moisture or ice crystals typically found in convective turbulence far away from storm clouds.

Laser-based radar, or lidar, is the second TPAWS technology under development (see "How Lidar Detects Turbulence," next page). Much more sensitive than Doppler radar, lidar can show air motion at a very high resolution, a capacity that gives Watson and his colleagues hope that—pending more refinement and development—it will be able to reflect off minute dust particles blown around by clear air turbulence. But after the attacks of September 11, 2001, as airlines lost passengers and were forced to spend

money on security, it became clear that developing an expensive technology like lidar would be difficult. "One of the challenges for a laser-based system is to make it more affordable," says Steve Hannon, chief scientist of CLR Photonics, a Colorado firm that is working with NASA to develop turbulence warning sensors.

According to Hannon, most research has focused on 10- to 20-centimeter-diameter "pencil beam" lidar, which stays fixed straight ahead of the aircraft and merely alerts crews to the presence of turbulence, rather than more expensive scanning lidar, which sweeps across the path of the aircraft and returns an image of the air. It's still unclear whether pilots need to know the shape of turbulence, as opposed to just the fact that it is looming ahead.

"In reality, I think all [airlines are] doing is trying to have a more reliable, robust seat belt warning light, basically to get people buckled down, and to secure the cabin with enough advance warning," says Hannon.

The Doppler upgrade is closer to deployment than lidar, but both should give pilots and crews about 90 seconds of warning. NASA staff scientist Rod Bogue, a former manager of TPAWS, says that, based on recent experiments conducted on the length of time it takes to get passengers and flight attendants seated and buckled, 90 seconds is just about the right amount of time.

Another promising technology unrelated to TPAWS is the use of Next Generation Radar—a nationwide network of extremely powerful and sensitive Doppler radars—to detect turbulence. The National Weather Service, NOAA, the U.S. Air Force and Navy, and the FAA operate nearly 160 NEXRAD radars. Cornman is confident that the FAA will fund an NCAR project for this year in which NEXRAD

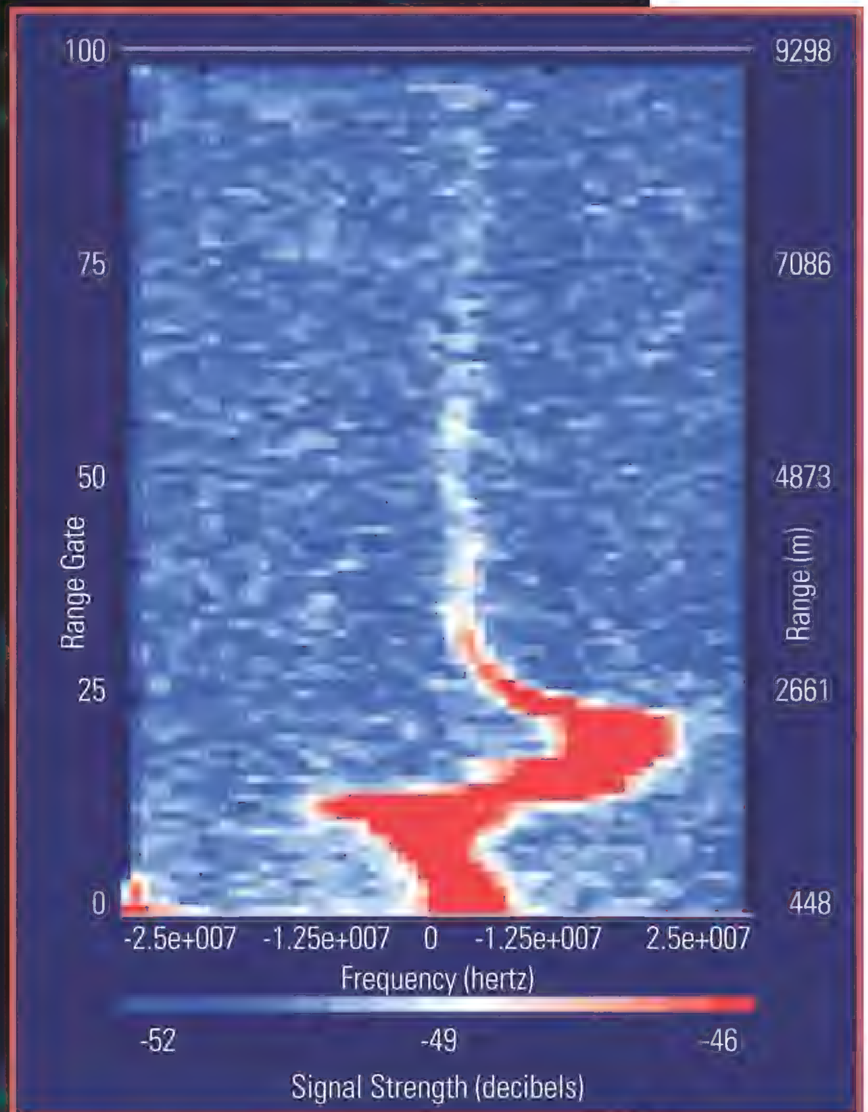
How Lidar Detects Turbulence

Like radar, lidar (light detection and ranging) can calculate objects' distances, speeds, and rotation rates by directing electromagnetic pulses at them and measuring the pulses that are reflected back. In the case of turbulence detection, the objects are tiny atmospheric particles. But unlike conventional radars, which send radio waves, lidar uses laser light, with wavelengths 10,000 to 100,000 times shorter.

The advantage of lasers is that laser light rays travel parallel to one another in a tight beam, as opposed to a radar's radio waves, which diffuse in all directions. The concentration increases the odds that the laser light will hit and reflect off of dust and other minute particles—known as aerosols—that lie directly in a lidar beam's path.

Lidar is thus ideal for detecting clear air turbulence, which has only tiny particles, not large water droplets, to reflect radiation. But for the very same reasons, lidar cannot help in examining the interior of a storm; the laser light would be reflected entirely by the outermost layers of clouds or rain. To see through moisture, conventional radar works better.

To detect CAT, lidars shoot laser pulses into the air ahead of the aircraft, where aerosols are being carried in the same direction and at the same velocity as the wind. The speed of the aerosols is measured by observing the Doppler shift of the laser reflections. If the aerosols are moving away, the returning light waves will have a lower frequency and longer wavelength than those of the original laser light; the shift will be toward the higher frequencies and shorter wavelengths if the aerosols are approaching the laser. By comparing the relative motions of aerosols in a beam's path, computers on aircraft can predict when CAT is imminent.



AVSSP

The Airborne Coherent Lidar for Advanced Inflight Measurements team, a joint venture involving NASA, NCAR, and Coherent Technologies, among others, captured this screen shot of lidar reflections in a 1998 flight test. Aerosol reflections, coded red, trace the relative speed of the wind, which is measured along the horizontal axis, with increased speed to the left of center and decreased speed to the right of center. Distance ahead of the aircraft—out to 9.3 kilometers (5.7 miles)—is measured along the vertical axis. At about 1.3 kilometers in front of the aircraft, relative wind speed increases, then decreases rapidly, indicating a wind shear of 20 meters per second (45 mph), which could cause a moderate bump.

data from around Chicago will be quickly posted online for United's dispatchers and meteorologists. "The other aspect of the program that we're also talking to United about is to uplink this data to the cockpit," says Cornman. Printers in the cockpit could spit out alerts that would inform pilots about turbulent conditions along their approach paths.

"Basically we tell our students that whenever possible, just avoid turbulence," says Mike Corradi, chief flight instructor at Embry-Riddle. "That way, you'll never have to prove your superior talents as a pilot."

Even moderate turbulence poses unwelcome piloting challenges, a point made soberingly clear when Corradi straps me into the left seat of a flight training device. Unlike a flight simulator, the device doesn't mimic the sensation of motion, but the 220-degree wrap-around screen showing computer-generated flight in real time provides an extremely realistic illusion of it.

After a relatively smooth takeoff, I level off at 8,000 feet, gazing at the detailed scene around and "below" me. The instruments on my control panel are all steady, calm, and easy to read. Then Corradi switches on the turbulence input, dialing up to 3 on a scale going up to 10. The horizon starts to bounce, pitch, roll. My instruments—when I can read them—indicate constant yawing. The scenery dances. It's all I can do just to maintain a semblance of level flight, which gradually slips from my grasp as I try to right the aircraft according to the instruments. Finally Corradi freezes the screen image and tells me to look up, saying, "Now, this is a picture you never want to see." I'm locked in a bank of more than 30 degrees, a mountain range is at eye level and about a mile dead in front, and I've been steadily losing altitude.

I'm not a pilot—and the flight training device is simulating a small aircraft—but it's not much easier for professionals flying big jets. "I can tell you, it's very fatiguing to be in turbulence for a long period of time," says Terry McVenes, an Airbus A320 pilot for U.S. Airways. Fatigue can undermine concentration, and in areas of high turbulence, pilots must constantly be at the controls; a good jolt to the aircraft can disengage an autopilot system. More recent and sophisticated autopilot systems can handle it, but many pilots prefer to fly manually through turbulence because it gives them a better sense of control.

When a flight hits turbulence that is moderate or worse, pilots follow certain procedures and then pursue options. First, they turn on the seat belt sign in the cabin, perhaps even make an announcement. Then they slow the aircraft down, just as a driver brakes when hitting a bumpy road. "All aircraft have a turbulence penetration speed," McVenes says, referring to a manufacturer's recommendation of an optimal speed for flying through bad air. "If you're in the passenger cabin, you'll hear the engines back down."

After alerting the cabin, says Hank Krakowski, a veteran pilot for United, "I talk to air traffic control to see what they know about turbulence in the area and if changing altitude makes sense." Air traffic control usually has some knowledge of any recent reports about turbulence at various altitudes. If the turbulence is on the downwind side of a thunderstorm, Krakowski, per United policy, has to double the wind speed at his altitude to determine the number of miles he must keep between him and the storm. For instance, if the wind speed is 23 miles per hour, he must fly at least 40 miles away from the lee side of the storm. "Once I've gotten into smooth air," Krakowski says, "I then let United dispatch know I've changed altitude and then see the effect it's going to have on my fuel."

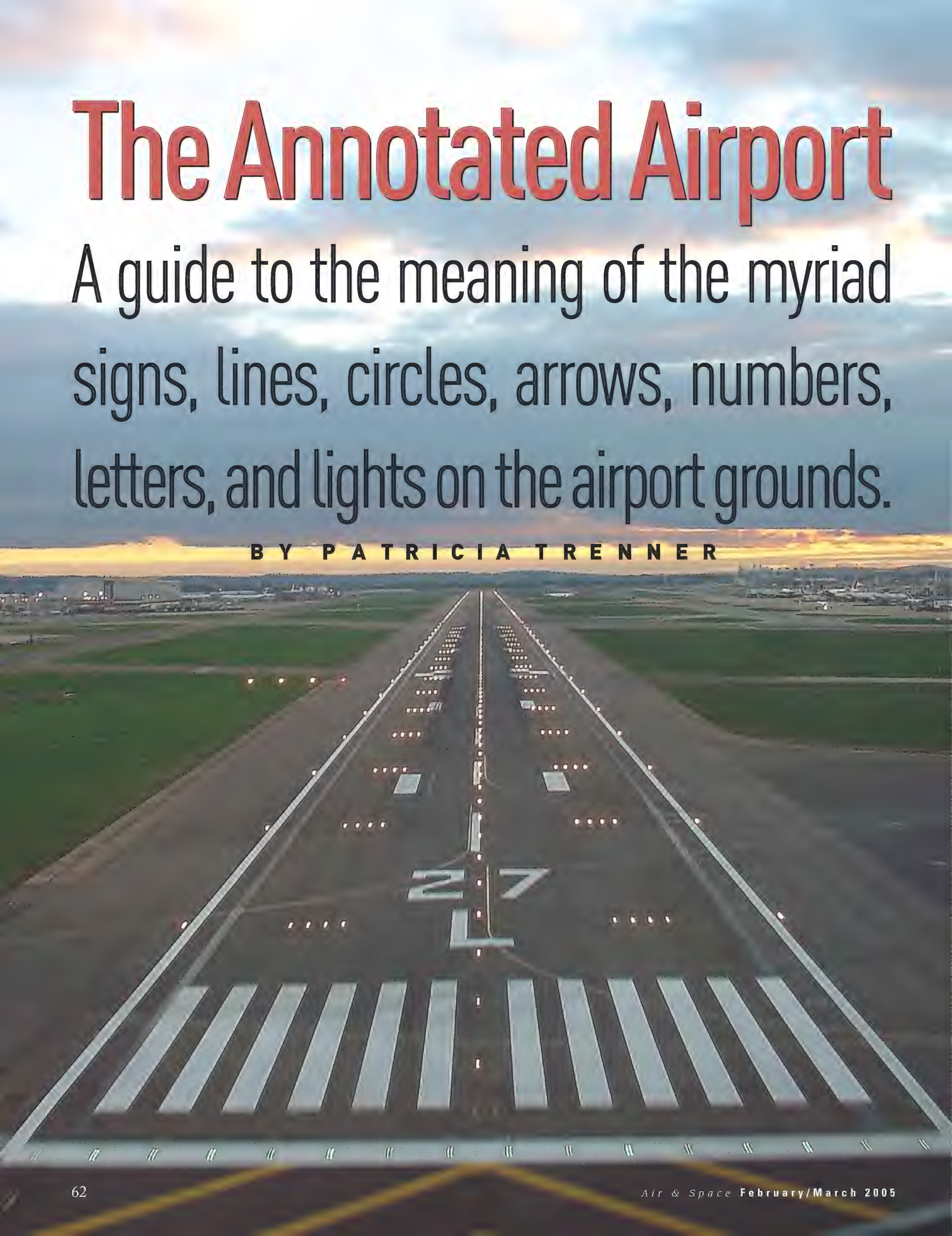
In other words, the numbers game begins again. If the lower altitude is going to eat up so much fuel that Krakowski may find himself in a dangerous situation should he have to enter a hold at his destination—or worse, have to divert—he may later climb back up and stay there, provided the turbulence is not severe. "While you want to create a great experience for the customer, the most important thing we do for them is get them to their destination and connections on time," he says. "So sometimes they have to live, as we do, with the foibles of the atmosphere."

"It's very fatiguing to be in turbulence **for a long period of time," says an airline pilot. Fatigue can undermine concentration, and in areas of high turbulence, pilots must constantly be at the controls; a good jolt to the aircraft can disengage an autopilot system.**

The Annotated Airport

A guide to the meaning of the myriad signs, lines, circles, arrows, numbers, letters, and lights on the airport grounds.

BY PATRICIA TRENNER



OPPOSITE: ©DANIEL M. LOPES; RIGHT: ©LUIS ROSA

As an airliner makes its way around an airport from the terminal to takeoff and, after the flight, back to the terminal, it encounters cryptic messages at every turn. To passengers, they may as well be hieroglyphs, but pilots understand them well, having been required to learn a second language: Airportese.

Airport Grounds

A **rotating beacon**, intended to be seen from the air, that flashes white and green, says, "This is a civil airport." One green and two white flashes means "military airport"—no civil aircraft allowed. White and yellow signifies "water airport"—floatplanes and flying boats only. Green, yellow, and white indicates "heliport"—rotary-wing aircraft only.

H Helicopter landing area

The **elevation notice** tells pilots this airport is, for example, 1,050 feet above mean sea level. The pilots make sure their altimeters agree.

A crew can taxi to the **compass rose**, align with a spoke, or bearing —90 degrees, for instance— and check to see if the compass reads 90. (If it doesn't, the compass needs to be recalibrated.)

The **wind sock** is a fabric or plastic cone that shows which way the wind is blowing. Aircraft take off and land into the wind. Taking off or landing with a tailwind increases the amount of runway required to lift off or come to a stop.

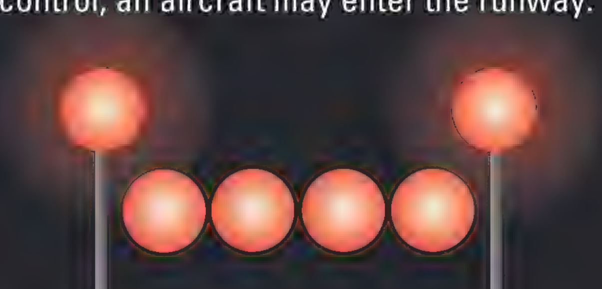
Lights

Blue lights outline a taxiway. **Green lights** run down the center.

White and yellow lights outline a runway. White lights run down the center.

Runway end identifier lights, a pair of synchronized flashing lights on each side of a runway threshold, indicate the approach end of a runway.

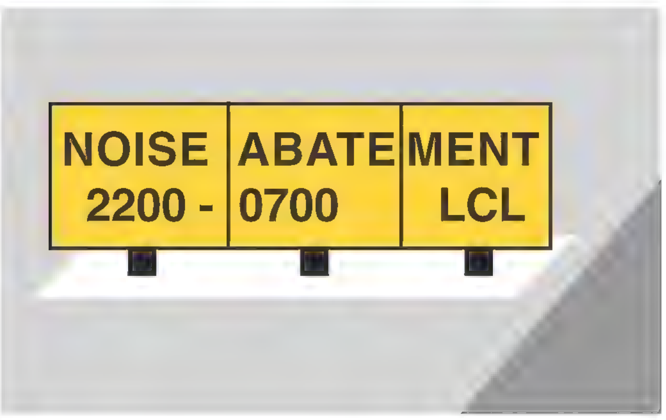
Stop bar lights are the row of red lights at a holding position where a taxiway meets a runway. When they go dark, accompanied by clearance from ground control, an aircraft may enter the runway.

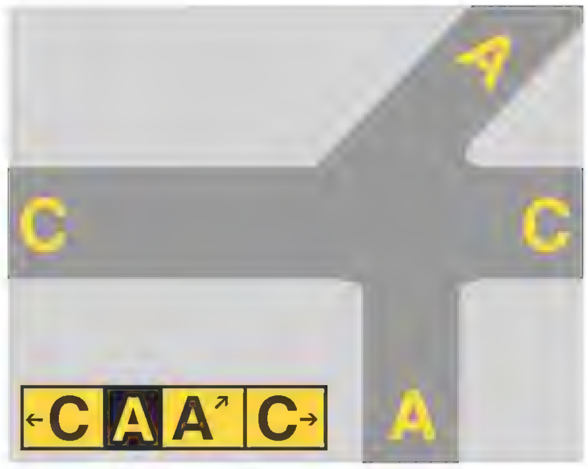


RUNWAY ICON GRAPHICS: ALEX REARDON

Taxiways

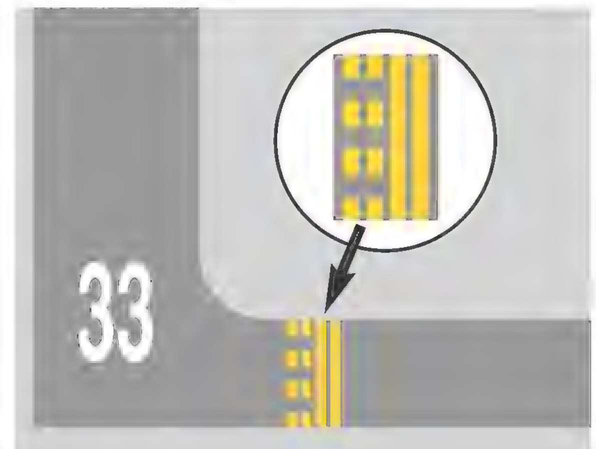
Noise Abatement 2200—0700 LCL Follow noise abatement procedures between 10:00 p.m. and 7:00 a.m. This may require the pilot to maintain a best-angle-of-climb attitude after takeoff (which puts the aircraft at the highest altitude in the shortest horizontal distance), or a best-rate-of-climb (a gain of the greatest altitude in the least time); in other cases, it may require a takeoff at less-than-maximum power, or refraining from applying full power until the aircraft is, say, 10 miles from the airport. Noise abatement procedures lower the decibel levels for the surrounding community.





Taxiway Alpha (A) A location sign, which tells you the taxiway or runway you are currently on, has yellow letters on a black square, the opposite of destination and direction signs. Here, Taxiway Alpha continues, angled to the right. Taxiway Charlie (C) runs to the left and right.

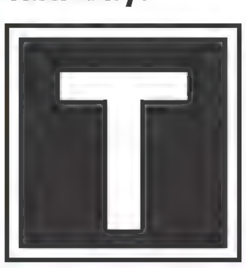
Runway holding position Stop here and do not move until ground control clears the aircraft to enter or cross the runway.



ILS Instrument Landing System critical area holding position. When instrument flight rules are in effect, ground control may hold an aircraft at this sign so it does not interfere with ILS signals.

Taxiway ends.

T This is a **taxiway**.

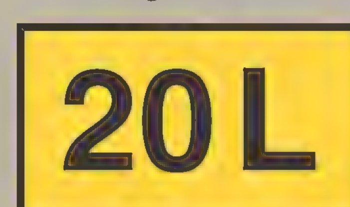


MIL/TERM/ CARG/RAMP Military, terminal, or cargo ramp (an aircraft parking area, also called an apron) facility is this way.

HS-1 Hold short (do not move until ground control tells you to) of the runway here.

Runways

This runway, with a compass heading of about 200 degrees, is the left (L) of two parallel runways. Each runway is numbered by its compass heading rounded off to the nearest 10 degrees, with the last digit dropped. A runway that heads due north, 360 degrees, is numbered 36. The opposite end, which heads due south, 180 degrees, is 18. (Because Earth's magnetic field changes over time due to the flow of the planet's molten iron core—in fact, the poles swap places on average every 200,000 years—runway numbers are changed as Earth's magnetic north pole wanders and field lines change the magnetic variation locally. For example, in 1999, Ronald Reagan Washington National Airport's runway 18-36 became 19-1.)



4,000 feet of runway remain.

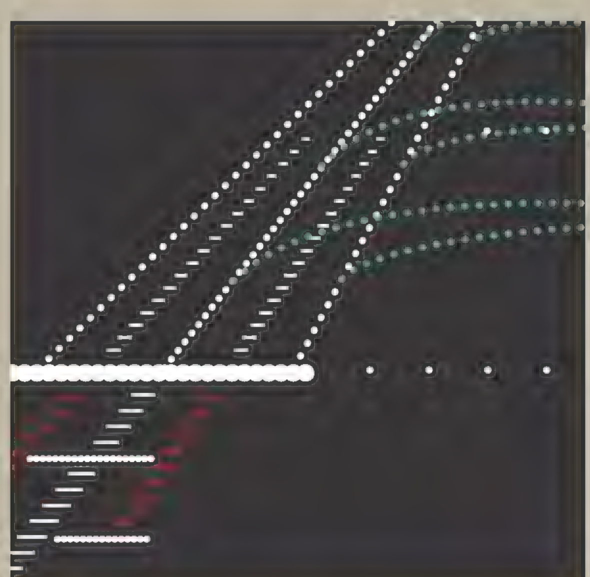
If a crew is hopelessly lost, it might employ the bluff used in what is probably an aeronautical urban legend. Back when New York's Kennedy airport was called Idlewild, a couple of neophyte pilots in a light aircraft requested taxi instructions for takeoff. Ground control responded with a hideously complex series of instructions involving turns at what seemed like a couple of dozen intersections. The frequency was silent as the pilots looked at each other cross-eyed and fumbled for a response. Finally, the copilot's voice rang out over the radio, "Aw, the heck with it. Tell him 'Roger.' "

A better solution would be to ask ground control for a "progressive taxi," in which a controller will provide taxi instructions to the pilot at each intersection encountered at the airport.

COURTESY WILSON AND COMPANY

You are on **Runway 22.** Remember, "black square, you're there."

Aircraft **may not enter** this area.

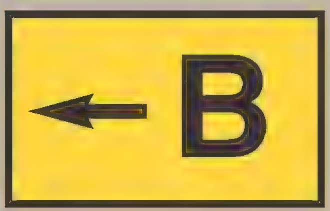


High-Speed Exit markings After landing, follow the green lights to make a high-speed exit from the runway.

4 arrowheads This runway is 100 feet wide
2 arrowheads less than 60 feet wide
Alternately:
4 threshold stripes This runway is 60 feet wide.
16 threshold stripes 200 feet wide.

A series of yellow chevrons: The runway threshold is "displaced." Land beyond here.

Touchdown zone markings: Pilots should try to put the main landing gear on the runway here.



B Exit B (Bravo) off the runway is just ahead, on the left.

X on runway (or taxiway): Closed.

OLD SLOW and UGLY

Before radar took over, OS2U Kingfishers were the eyes of the fleet.

by James L. Noles, Jr.

Slow, maybe. But ugly? OS2U-3s fly their version of a beauty shot.

Rear Admiral Robert C. "Ike" Giffen assembled a small group of pilots on the deck of the USS *Massachusetts* in the predawn darkness. Giffen was a commander in a formidable invasion force gathered off the coast of North Africa on November 8, 1942. His mission, known as Operation Torch, was to create a second front against the German forces, but in order to begin the invasion, he'd need the pilots of his aviation detachment to scout for vital information: Would the Vichy French in Morocco, with troops entrenched ashore, and the battleship *Jean Bart* and five submarines in the harbor, resist the U.S. landing? In the days leading up to the invasion, a U.S. Army general had attempted to negotiate an agreement. If the pro-Vichy forces in Casablanca decided to defy their German overlords by not fighting the Americans, they would signal their decision with a white flag. "The admiral told us to reconnoiter the French positions and look for that flag," says Thomas Dougherty, recalling that morning 62 years ago. Dougherty, who today lives in Duluth, Minnesota, was an ensign and a pilot of one of the battleship's two Vought-Sikorsky OS2U-3 Kingfishers. "If we encountered enemy action, we were to call 'Batter up,' and the ship would answer 'Play ball,' to let us know they were launching an attack." In the event of an attack, Dougherty's job as a Kingfisher pilot was to be a "spotter," responsible for directing the fire of a battleship's guns by overflying a target and spotting the shells as they landed. If the shells fell short or too far to the right or left, the pilots would call back with corrections.

When Dougherty flew over the French fleet moored in the harbor, he saw no white flag. Instead, the inexperienced pilot was greeted with what he thought were fireworks. "What did I know?" he remembers. "I was just fat, dumb, and happy, wondering who was celebrating down there. Then, when an explosion's concussion just about knocked me over, I realized they were shooting at me!" He immediately radioed "Batter up" to the *Massachusetts*, and within moments, the ship's big guns were hammering away at the *Jean Bart*.

Dougherty soon came under attack from a French fighter aircraft, and the Kingfisher's canopy disintegrated in a hail of bullets. "If I had had my seat raised one notch higher," Dougherty declares, "I wouldn't be talking to you today." He splashed down safely in the harbor and was taken prisoner by the French. His radioman, Robert Etheridge, was wounded in the attack and taken to a hospital. Eventually, Dougherty and Etheridge were returned safely—Dougherty after only five days of captivity.

COURTESY JAMES W. DAVIS

USS Salt Lake City*'s Kingfisher detachment. Robert Epperson is top row, fifth from left. Jim Davis is bottom row, second from left.*

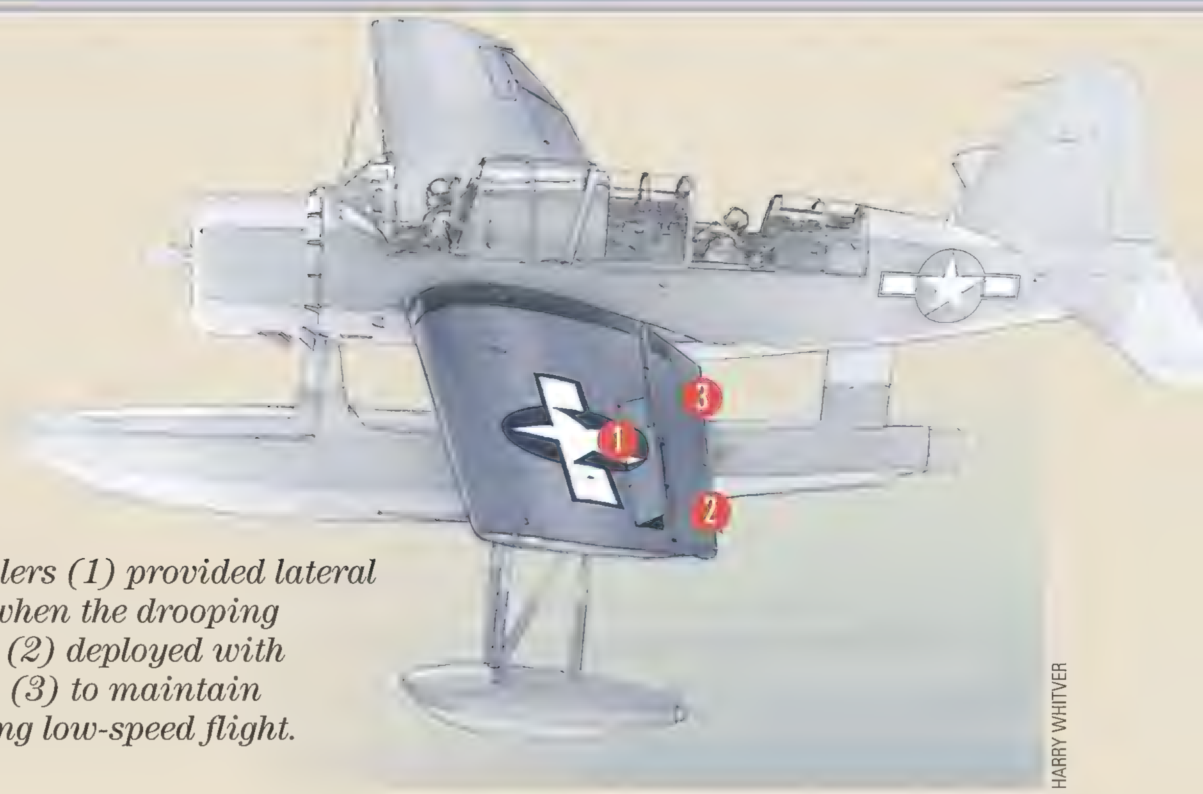
Birth of an Icon

Directing battleship fire was precisely the kind of mission for which Rex B. Beisel had designed the Kingfisher five years earlier. A Vought-Sikorsky engineer who went on to design the F4U Corsair, Beisel incorporated innovations in the Kingfisher, the first monoplane ever to be launched from a shipboard catapult, that would make it the U.S. Navy's primary ship-based observation aircraft during the Second World War. It was the first to be assembled with spot-welding, a process Vought and the Naval Aircraft Factory jointly developed to create a smooth fuselage that resisted buckling and generated less drag. Beisel also introduced high-lift devices to keep the aircraft controllable at low speeds. Deflector plate flaps and special drooping ailerons were located on the trailing edge of the wing and were deployed in concert with one another to increase the camber of the wing and thus create additional lift. The spoilers then took over the ailerons' job by providing lateral control during low-speed flight (see illustration, next page).

For armament, the Kingfisher carried a .30-caliber machine gun, the breech of which, along with the ammunition can, was in the pilot's compartment. Sitting behind the pilot, the radio operator/gunner manned another .30-caliber machine gun (or a pair) on a flexible ring mount. The airplane could also carry two 100-pound bombs or two 325-pound depth charges.

Beisel's first prototype flew in 1938, powered by an air-cooled, 450-horsepower Pratt & Whitney R-985-4 Wasp radial engine. Within two years, Vought-Sikorsky delivered the first production Kingfisher, an OS2U-1, to the battleship USS *Colorado*. Another 54 OS2U-1s and 158 OS2U-2s soon joined the Navy's ranks. The OS2U-2 variant differed slightly from its predecessor,

NASM (SI #X00097480)



The spoilers (1) provided lateral control when the drooping ailerons (2) deployed with the flaps (3) to maintain lift during low-speed flight.

HARRY WHITVER

boasting additional fuel tanks and stronger armor. Confronted with the squat monoplane—some with wheels, others with floats, and still others with wheel-float conversion kits—Navy pilots quickly christened it "the Bug" or, in mockery of the designation OS2U, "Old Slow and Ugly."

"Slow" was right—it was a lucky pilot who could coax speeds of more than 166 mph out of the Kingfisher. A crafty pilot could, however, work the Kingfisher's slow speed to his advantage. Joe McGuinness was flying a Kingfisher from the light cruiser USS *Birmingham* over Japanese-occupied Wake Island when a Zero jumped him. McGuinness immediately reduced his airspeed to just above stall speed. "We were almost falling out of the sky," recalls the retired naval aviator. He turned the Kingfisher toward the oncoming Japanese fighter in order to give his gunner a good shot at the enemy pilot. "He [the Zero] was going too fast, and just skidded right over us. My gunner was shooting at him, but we didn't stick around to see if we hit him or his airplane."

Even as the new aircraft were reaching the fleet, Vought-Sikorsky continued to tinker with the Kingfisher's design. On May 17, 1941, the first of the OS2U-3s flew, powered by a 450-horsepower Pratt & Whitney 985-AN-2 radial engine.

The Kingfisher's landing speed was a remarkably slow 55 mph, thanks in part to low wing loading and a 262-square-foot wing area.

NASM (SI #2003-11333)

Slow, Steady, and Stable

"It was a very stable aircraft," recalls James W. "Jim" Davis Jr., who flew Kingfishers off the cruiser *Salt Lake City*. "Very slow, but very stable. They said you could loop it, but with those big floats, I wasn't going to push it. The Kingfisher was a good airplane for its purpose [spotting and observation] because you could see everything that was going on."

Hundreds of Kingfishers served strictly as landplanes at training bases in Pensacola and Jacksonville, Florida, and Corpus Christi, Texas. Fifty-three others found homes at various U.S. Coast Guard air stations, where they flew anti-submarine and convoy escort missions along the coasts of the United States. The Kingfisher shared its scouting and observation duties with the SOC Seagull, a slow but graceful biplane built by Curtiss Aircraft Company. Pilots familiar with the SOC appreciated its superior fuel economy and rate of climb, although they relished the Kingfisher's excellent radios, especially on long hops over the ocean.

"Both were reliable aircraft," says William Neufeld, author of the book *Slingshot Warbirds* and the younger brother of a naval aviator who flew both types of aircraft. Neufeld concedes that the Kingfisher could be "a little more temperamental" than the SOC. Later, the SC-1 Seahawk joined the fleet as another catapult-launched aircraft. Nevertheless, it was the omnipresent Kingfisher that was destined to become the Navy's iconic floatplane of the Second World War.

The Kingfisher's tasks were legion: They included scouting, bombing, strafing, anti-submarine patrols, search-and-rescue, training, and even odd jobs such as towing aerial gunnery targets. Capable of remaining aloft for over five hours, the Kingfishers could range 400 miles from their ships to scour sky and sea for the enemy.

John Marocchi served aboard the USS *Birmingham* while the light cruiser supported U.S. amphibious operations in Sicily, and later in the Pacific. During the invasion of Saipan and Tinian in June 1944, he worked the cruiser's main-battery fire-control computer, a massive machine of wheels and dials. For him, the Kingfishers were indispensable. "We used the reports from the plane spotters to correct aim points," Marocchi explains. "During pre-landing bombardments, the plane spotters were very effective. And once our troops were ashore, the planes spotted for us beyond what could be observed from the ground."

Almon P. "Al" Oliver, a pilot stationed on the battleship *North Carolina*, remembers that the ship's gun crews would begin a fire mission by firing a single round, then radioing the word "salvo." Just before the shell was expected to land, Oliver recalls, the crew called "stand-by," to alert the pilot to observe the shell land, then as the shell was expected to land, "splash." "As the firing continued, the pilot would call out any corrections necessary to put the shells on target, at which time he would report 'No change, no change.'"

Ready, Aim, Launch!

For Kingfisher crews assigned to the Navy's warships, missions began literally with a bang.

"Aircraft were launched from the ship by a catapult operated by gunpowder," explains Oliver. Battleships and cruisers were, at the time, typically outfitted with two stern-mounted catapults for such purposes. The Navy even equipped some destroyers with them, although the smaller ships had to give up a gun turret and the torpedo tubes , to make room for the catapult. "An eight-inch shell filled with black powder was fired into a cham-

COURTESY JOE MCGUINNESS

Joe McGuinness trained at the Jacksonville Naval Air Station in Florida in 1942.

It was a lucky pilot who could coax speeds of more than 166 mph out of the Kingfisher. A crafty pilot, however, could work the airplane's slow speed to his advantage.

Curtiss Aircraft Company's SOC Seagulls scouted with Kingfishers.

NASM (SI #A-4263-A)

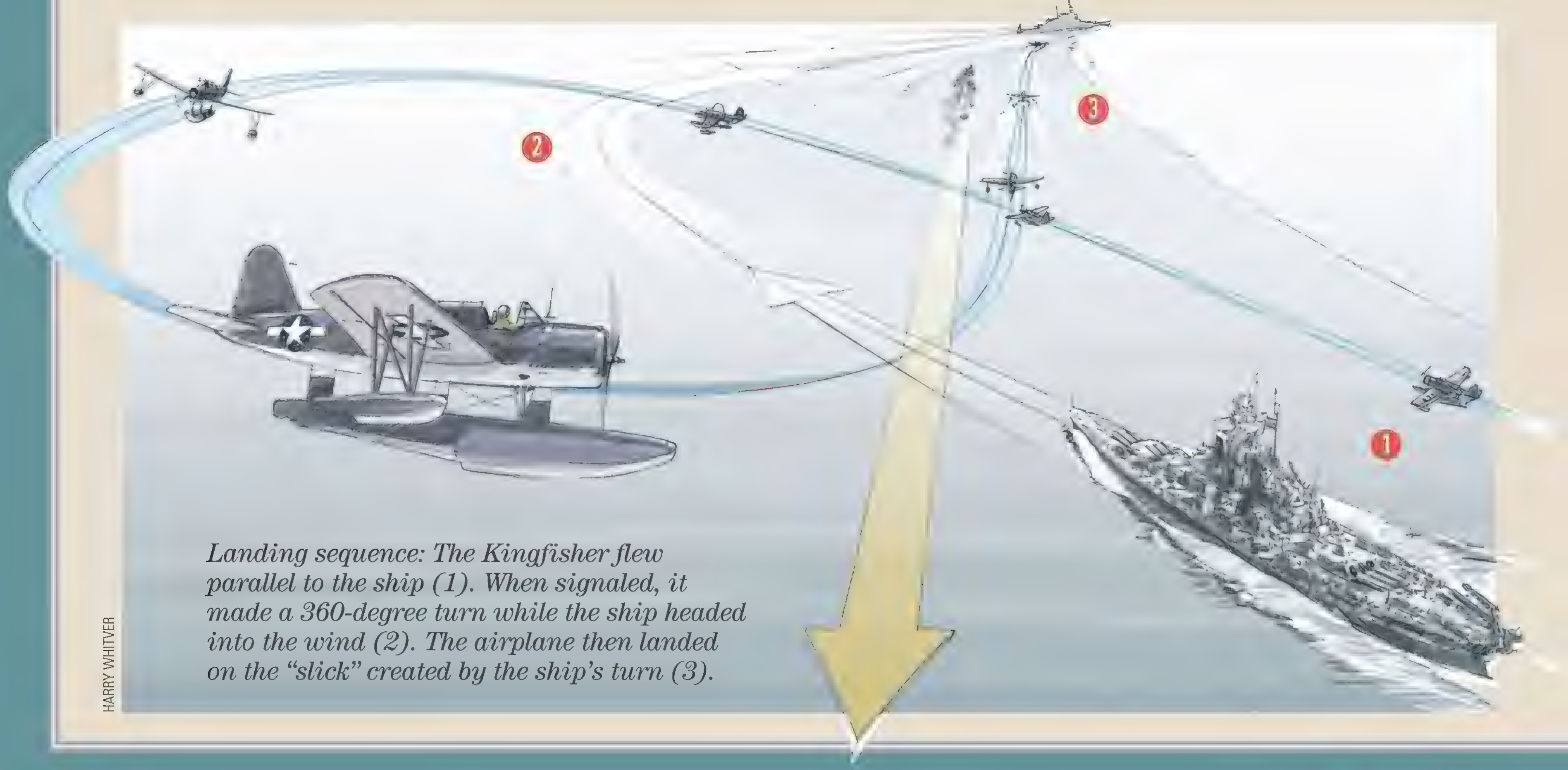
Getting into the air was only part of the battle. Even with experience, landing a Kingfisher in the ocean could be a challenge.

NAVAL AVIATION HISTORY OFFICE

ber, and by the movement of a piston [and] a series of pulleys and cables, a cradle holding the plane was literally fired down the catapult track," says Oliver. "This amounted to being fired from a cannon, since the plane accelerated from zero to 60 knots within a few feet.

"It was a sturdy aircraft and could take a lot of punishment," he adds. "We may have called them 'low and slow,' but they were rugged.

"Prior to launch," Oliver continues, "the ship would turn to a heading that would place the relative wind about 30 degrees off the bow. The catapult would then be trained outboard to put the wind directly down the track." When crews wanted to launch two Kingfishers in rapid succession, they expedited the process by loading both catapults, starboard and port sides. "The ship would turn so that the starboard catapult was facing into the wind, and launch that Kingfisher first. Then they rotated the port-facing catapult 90 degrees so that it now also faced the starboard side, and launch that Kingfisher as well. This process avoided the labor-intensive maneuver of changing the ship's direction, and enabled us to launch quickly."



Landing sequence: The Kingfisher flew parallel to the ship (1). When signaled, it made a 360-degree turn while the ship headed into the wind (2). The airplane then landed on the "slick" created by the ship's turn (3).

HARRY WHITVER

NAVAL AVIATION HISTORY OFFICE (2)

A pilot has attached the hook from a shipboard crane so the Kingfisher can be hoisted onto the deck (left). Before a recovery (opposite), the pilot taxied, sometimes in rough water, to engage a "sled" with a spring-loaded hook on the airplane's main float.

Robert Epperson served as a radio operator-gunner with *Salt Lake City*'s Kingfisher unit. He recalls the explosive moment of launch from inside the aircraft. "The pilot would clamp his hand down on the throttle, stick his elbow back in his stomach, and lock his head back in a headrest," he says. "In the back, I would put my head down in my lap, cross my arms over it, and grasp a pair of handles with my hands.

"When we were catapulted from amidships, the force was fantastic. Anything that happened to be loose in the cockpit—in fact, just about anything in the cockpit—became a projectile. For the first few seconds after launch, you were busy putting radios and spare ammunition cans back where they belonged so that those things weren't jamming the controls."

Of course, getting into the air was only part of the battle. Even with experience, landing a Kingfisher in the ocean could be a challenge.

"Swells in the landing area are predictable," Oliver explains. "[Usually] they can be judged by the pilot and pose no big problem to operations unless they are extremely high." In the choppiest waters, the ship created a "slick," a wake of relatively calm water, by making a sweeping turn to one side. The airplane flew a pattern parallel to the ship's course at 500 feet, with the ship flying a signal flag at half mast. A green flag on the starboard yardarm indicated to the pilot that recovery would be made on the ship's starboard side, while a red flag on the port yardarm indicated a port-side landing. When the airplane was about a quarter-mile ahead of the ship, the "C" flag—"Charley" flag in Navy parlance—was waved to signal the pilot to begin the landing sequence.

"Upon signal to execute, the airplane started a circling 360-degree approach and the ship executed a maximum-rate turn of 90 degrees," says Oliver. "A crewman on the fantail threw a smoke flare overboard so that the pilot could align his approach and land into the wind, as close to the ship as possible" (see illustration, opposite).

After landing, the pilot taxied to a "sled," towed from a boom near the stern. The sled, which measured about 10 feet wide and 20 feet long, was more of a heavy rope tied into a series of one-foot squares. A spring-loaded hook attached to the bottom of the Kingfisher's main float engaged the sled, and the plane was towed until a sling

The gunpowder-driven catapult was noisy enough to make onlookers plug their ears. The force of the catapult propelled the aircraft to a speed of about 70 mph.

NAVAL HISTORICAL CENTER

A Kingfisher overflies the first wave of the invasion of Angaur, Palau Island, in September 1944.

from the cockpit was attached to an aircraft crane on deck. The airplane was then hoisted on board and placed in a cradle atop the catapult track.

Scout, Search, and Rescue

Meandering over enemy lines for hours at a time to call in naval gunfire on obstinate enemy positions, the Kingfishers endeared themselves to the troops slugging it out with the Japanese below. But few men held the Kingfisher in higher esteem than the downed naval aviators who relied on "Old Slow and Ugly" to save them from capture or death. An incident related by Oliver from the last days of the war represents countless such episodes in the Pacific.

On August 10, 1945—the day after the atomic bombing of Nagasaki—hurried orders scrambled Oliver off the *North Carolina* to rescue a Navy pilot who had ditched off the Japanese island of Honshu. Before he even had time to plot a decent course, Oliver blasted off the catapult. Another Kingfisher, piloted by Lieutenant Ralph Jacobs, linked up with him for the rescue. To free up space, both men flew without backseat gunners. Instead, eight fighters flew escort overhead.

Dodging friendly fire from a U.S. submarine, quickly followed by heavy anti-aircraft fire from Japanese shore positions, Oliver and Jacobs spotted the downed aviator, Lieutenant (Junior Grade) Vernon Coumbe. Shot down the day before, Coumbe had spent a tense night a scant two miles from a major Japanese naval base.

Ordering Oliver to remain airborne, Jacobs braved high winds and choppy surf to splash down near Coumbe. Immediately, automatic weapons fire streaked through the air while shells plunged into the water around the Kingfisher. As Oliver took evasive action overhead, Jacobs taxied near the beach.

In April 1944, a Kingfisher rescued nine downed naval aviators in Truk Lagoon. Here, the aircraft approaches the submarine USS Tang *as the rescued fliers cling to its wings.*

US NAVY; NASM (SI #00097380)

"The airplane started what appeared to be a takeoff run into the wind," Oliver remembers. "I expected Jacobs' takeoff might be rough due to the choppy water, but the high wind would be helpful. Yet as I watched the plane run into the wind longer than I felt necessary and begin to bounce and porpoise, I became concerned and flew down alongside the plane. To my amazement, both cockpits were empty."

Turning back toward the beach, Oliver spotted both Jacobs and Coumbe struggling in the surf. While Jacobs had stood in the cockpit trying to help Coumbe on board, the blast from a nearby shell had dumped Jacobs out of the airplane. As he fell, he had inadvertently kicked the throttle wide open, and the aircraft took off unmanned, leaving him and Coumbe stranded on the hostile shore.

"I landed and taxied back, then turned into the wind, flaps down, and sailed backwards through the surf with the main float touching the beach," Oliver recounts. "Since the plane had only one seat in the rear cockpit, I yelled out to Jacobs that he should help the rescued pilot into the back seat and that I would send someone back for him." Jacobs understandably disagreed with Oliver's idea, and scrambled into the back seat along with Coumbes.

Within moments, Oliver's Kingfisher labored aloft. With its center of gravity so far aft, his aircraft "flew like a pregnant duck." It also burned fuel at an increased rate, so Oliver kept a careful eye on his fuel gauge. Some two and a half hours later, he landed alongside the *North Carolina* with what he described as "one cup of fuel" in the tank. For the three pilots, it had been a remarkably close call, and both Oliver and Jacobs received Distinguished Flying Crosses for their bravery.

The Kingfishers Retire

The end of World War II marked the end of the era of using catapults to launch aircraft from ships other than aircraft carriers. Increasingly effective anti-aircraft weapons, improvements in radar-controlled gunfire, and the asecendancy of the helicopter conspired to edge the slow, vulnerable Kingfisher off the stage. Today, some half-dozen Kingfishers reside in museums around the world, including the National Air and Space Museum's Steven F. Udvar-Hazy Center in Chantilly, Virginia. Kingfishers are also on display at the USS *Alabama* and the USS *North Carolina* battleship memorials, at the Naval Aviation Museum in Pensacola, Florida, and at museums in Havana, Cuba, and Santiago, Chile. These few exhibits are all that remain of the more than 1,500 Kingfishers that served during World War II.

Capable of remaining aloft for over five hours, the Kingfishers could range out for 400 miles from their ship to scour sky and sea for the enemy.

NASM (SI #00097413)

The OS2U-3 was the only variant exported. In all, 1,519 Kingfishers flew, bearing not only U.S. markings, but those of other countries, from Uruguay to Australia.

SIGHTINGS

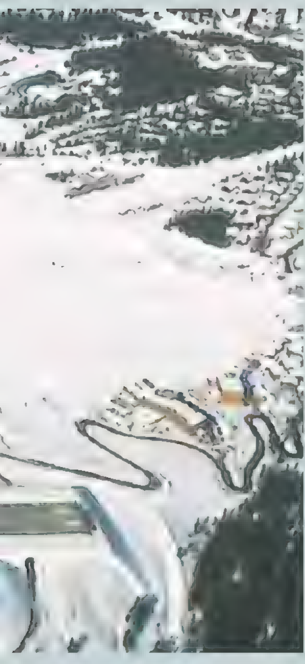
As if skiing the French Alps weren't thrilling enough, consider flying in and out of Courchevel Airport, or "altiport," as the 6,580-foot-high runway near the Italian border is billed. First there's the slope—an alarming 18.5 degrees for nearly half the runway's 1,755-foot length. "It's almost like ski jumping," says photographer Markus Herzig, who took these photos of a Tyrolean Airways de Havilland Canada Dash 7 coming (below) and going (bottom right). For much of the takeoff you'll basically be pointing down a mountain side.

Oh, and on the approach, you'll get only one chance. No go-arounds—there's a mountain at the end of the runway.

Dutch amateur photographer Dennis Kikkert, who was piloting a Cessna 172 when his friend Ramon Verberne took the photo of Courchevel's runway at top right, thought he'd give mountain flying a try during a vacation at nearby Les Trois Vallées, the world's largest ski area. First he and his friends skied all the way to the airfield from the Les Menuires resort, which is pretty cool in itself. Having recently earned his pilot's license, Kikkert signed up for a one-hour introductory mountain-flying lesson at the Aéro Club des Trois Vallées. Not just anyone can fly into Courchevel, and the level of training required depends on what you plan to do. "Mountain ski" lessons, for example, prepare you to land on snowy surfaces, and teach you "recognition of and arrival on glaciers."

Kikkert climbed into the Cessna next to instructor Robert Christin, "a kind man with a lot of flying experience," and was soon above the mountaintops at 9,000 feet, where he could see 15,800-foot Mont Blanc, western Europe's highest peak, in the distance. "While [we were] flying past the ski slopes, some skiers having a break in the sun were waving at us," he recalls. "I could almost see their faces, and felt a bit like a hero."

MARKUS HERZIG (2)



RAMON VERBERNE

MCDONNELL DOUGLAS

A rear arch on McDonnell Douglas' Sky Owl UAV guarded the propeller.

RoboProps

Unmanned Aviation

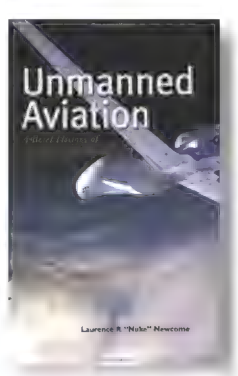
by Laurence Newcome. American Institute of Aeronautics and Astronautics, 2004. 166 pp., $42.95.

Attack of the Drones

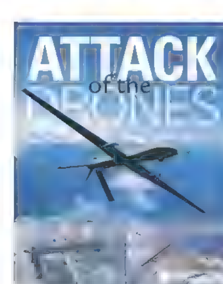
by Bill Yenne. Zenith Press, 2004. 128 pp., $19.95.

On November 2, 2002, a General Atomics MQ-1B Predator unmanned aerial vehicle under the remote command of U.S. forces in Djibouti tracked and destroyed a sport utility vehicle in the hill country of neighboring Yemen, killing the six al-Qaeda fugitives inside, including the man thought to have masterminded the 2000 bombing of the USS *Cole*. It wasn't the first time a Predator fired its wing-mounted AGM-114 Hellfire anti-tank missiles at a target, but it was the first such attack to attract intense media coverage and trigger notoriety.

Two new books provide context for such robotic aerial warfare through a chronological study of the history and possible futures for UAVs. Viewed as a landmark in a development process that in some aspects started as early as the 1800s, the take-down in Yemen becomes not so much a first as the logical result of refined UAV tactics and increasingly more sophisticated vehicles.



Assertions that events like the one in Yemen were indeed "firsts" inspired Laurence Newcome to write *Unmanned Aviation*. He expresses fears that lessons learned from past conflicts have been "lost in the ashes" as robotic aircraft "fade back into obscurity" after each conflict, despite advancements in the technology used on the vehicles. His goal in this book is thus to help future UAV developers save taxpayer money by not reinventing the wheel. Using a steady stream of fascinating facts and unveiling connections between modern-day manned aircraft and their unpiloted brethren, Newcome reaches aerospace engineers and non-technical readers alike, despite the no-nonsense writing style and drab black-and-white photographs and illustrations. The book's believability is anchored by Newcome's long-time association with UAV development at the Pentagon and in the private sector; even so, his offering comes across as unbiased and untainted by military jargon and euphemisms.



Aviation writer Bill Yenne, on the other hand, at times pays undue homage to the military machine at the expense of objectivity in his book, *Attack of the Drones*. It's a style military enthusiasts may find appealing but general readers may interpret as arrogant. On the positive side, Yenne's book focuses on the United States' use of UAVs in combat, and he backs up his eloquent style with contemporary full-color photos of the aircraft in action in Afghanistan and Iraq.

—John Croft is an aerospace engineer and freelance aviation writer in Upper Marlboro, Maryland.

ON TELEVISION

Nova: A Daring Flight

Airs on PBS February 22, 2005. Check local listings for time.

Nova's program simultaneously traces French aviation pioneer Louis Blériot's development of a truly airworthy craft and his grandson's attempt to re-create, in a vintage Blériot XI monoplane, his grandfather's 1909 flight across the English Channel.

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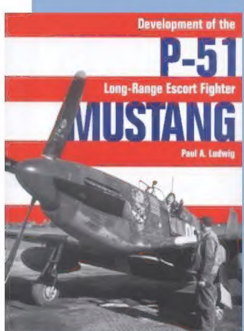
BRIEFLY NOTED

Alaska's Bush Planes

by Ned Rozell. Alaska Northwest Books, 2004. 80 pp., $14.95.

Filled with airplanes you wish you owned buzzing dogsleds and dodging glaciers, this pint-size delight will stir up fantasies of skipping out on life in the Lower 48 and escaping via Piper Cub to Alaska.



P-51 Mustang: Development of the Long-Range Escort Fighter

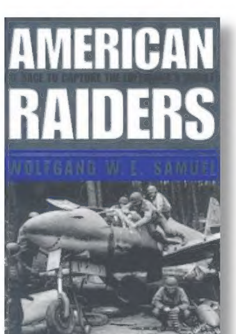
by Paul Ludwig. Classic Publications, 2004. 224 pp., $64.95.

Hundreds of fabulous photos (most in black and white), a dozen portraits by artist Tom Tullis, and a sometimes hard-to-follow text make up this book for the Mustang lover's coffee table.

American Raiders: The Race to Capture the Luftwaffe's Secrets

by Wolfgang Samuel. University Press of Mississippi, 2004. 493 pp., $35.

In April 1945, Boeing was ready to build a prototype B-47, hoping to snag the contract for America's first turbojet bomber. A Boeing aerodynamicist, George Schairer, happened to be in Europe that month, helping the U.S. military understand German technology before the Japanese could deploy it in the Pacific. Germany had not yet surrendered, and everyone expected the Japanese to fight on for years.



When U.S. troops captured the Hermann Göring Institute in Völkenrode, Schairer was able to quiz the staff about an unusual aspect of their latest aircraft: The Germans explained that a swept wing raised the speed at which the wing began to buffet, enabling an airplane to gain an extra 50 or 75 mph before it ran into transonic turbulence. Schairer wrote home: Hold everything!

Boeing redrew its B-47, creating not only the quintessential jet bomber of the 1950s but also the basic design of its 707 transport and all the heavy metal that followed. Even the newest Boeing airliner, the 7E7—and the super-jumbo A380 from Airbus—owe a little something to that impromptu seminar at Völkenrode.

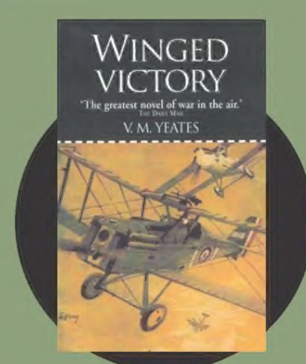
Wolfgang Samuel is uniquely qualified to write the story of how German technology came to the New World. The son of a Luftwaffe pilot, he immigrated in 1951 and became a colonel in the U.S. Air Force. Like many American and British writers, he has a tendency to glorify imports like the Messerschmitt 262 jet fighter. To be sure, Nazi Germany had the better engineers—fat lot of good they did. A bludgeon, not a scalpel, was the war-winning technology. Indeed, it can be argued that Germany's fascination with far-out designs contributed to its defeat, causing the country to fritter away resources that should have been devoted to more mundane weapons.

In any event, the war in the Pacific ended before either side could exploit the German technology. Far more important was the brain power behind that technology. The United States imported hundreds of scientists who became founding members of the U.S. aerospace industry: Wernher von Braun, father of the ballistic missile; Hans von Ohain, builder of the world's first operational turbojet; and Alexander Lippisch, designer of tail-less, delta-wing aircraft.

Samuel explains that in 1945, Russia too was scouring Germany for knowledge to exploit. If all those Germans had gone east instead of west, the cold war would have been waged on terms much less favorable to the United States.

—*Daniel Ford is the author of* Flying Tigers: Claire Chennault and the American Volunteer Group.

SHORT HOPS



Winged Victory

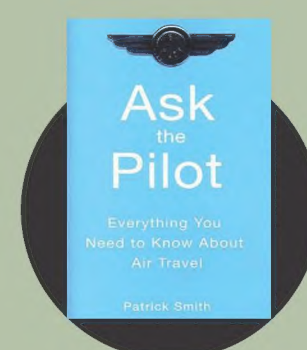
by Victor Yeates. Grub Street, 2004. 456 pp., $18.95.

During the 1940 Battle of Britain, Royal Air Force pilots so prized this long, funny, bitter novel (reprinted for the first time in 40 years; published for the first time in paperback) that they supposedly paid as much as £5 for a copy—more than most earned in a week.

Tom Cundall flies a rotary-engine Sopwith Camel in the last year of "the Great War." He's sick of combat, but he loves to fly, and he enjoys war's simple pleasures: "Lunch came along at one o'clock," Yeates disarmingly tells us, "and, having discussed with Hudson the relative merits of being shot down in flames and dying of cancer, he went to the hut to fill his tobacco pouch."

Cundall survives the war and is sent home with "Flying Sickness D"—tuberculosis, probably. The same thing happened to Yeates, who died of TB in 1934, six months after this, his only book, was published.

— *Daniel Ford*



Ask the Pilot: Everything You Need to Know About Air Travel

by Patrick Smith. Riverhead Books, 2004. 269 pp., $14.

The answer man behind the Ask the Pilot column at Salon.com, airline pilot Patrick Smith entertains conspiracy theories, explains fundamentals of flight and commercial jet operations, and provides answers to the mysteries behind airport codes, competing airlines, and pilot lingo. Can a 747 fly a loop? Is there much hanky-panky going on up there? Why are airplane seats so cramped?

Smith's brief essays cover a huge range of topics, and he speaks to airplane enthusiasts, disgruntled travelers, extreme aerophobes, and the merely curious, often in the same breath. The book collects question-and-answer exchanges from more than 100 online columns, addressing everything from post-9/11 security concerns to economy-class seating woes with optimism and humor, while aiming to restore a bit of glamour and dignity to commercial aviation. And if the book fails to answer everything you need to know, Smith is still taking questions at Salon.com.

—*Colin Bane*

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CALENDAR

February 5
Seminar on American Fliers in World War II England, featuring a P-38 Lightning flight demonstration. Planes of Fame Museum, World War II Cal-Aero Field, Chino, CA, (909) 597-3722, *www.planesoffame.org.*

February 19
Paper Airplane Flight School. Olympic Flight Museum, Olympia Regional Airport, WA, (360) 705-3925, *www.olympicflightmuseum.com.*

February 26 & 27
Northwest Aviation Trade Show. Sponsored by the Olympic Flight Museum. Puyallup Fairgrounds, WA, (360) 705-3925, *www.olympicflightmuseum.com.*

March 5
Seminar on Air Operations Over Iwo Jima, featuring a P-51 Mustang flight demonstration. Planes of Fame Museum, World War II Cal-Aero Field, Chino, CA, (909) 597-3722, *www.planesoffame.org.*

March 11–13
Tico Warbird Airshow. Flight demonstrations by modern military aircraft, including strafing runs and dogfights. World War II military aircraft on static display. Valiant Air Command, Titusville, FL, (321) 268-1941.

March 19
Military Collectibles Show and Sale. Olympic Flight Museum, Olympia Regional Airport, WA, (360) 705-3925, *www.olympicflightmuseum.com.*

Organizations wishing to have events published in Calendar should fax press releases two months in advance to (202) 275-1886 or mail them to Calendar, Air & Space/Smithsonian, *MRC 951, P.O. Box 37012, Washington, DC 20013-7012.*

CREDITS

Rogue Elephants. C. James Novak, a motivational speaker and executive coach (*www.summit-team.com*), is the author of *Conquering Adversity* (CornerStone Leadership Institute, 2004).

My Adolescent Aviator. Beth Mlady is a freelance writer living in Parma, Ohio.

The U-Deuce. William E. Burrows teaches journalism at New York University and writes about science and technology. His most recent book is *By Any Means Necessary: America's Secret Air War* (Farrar, Straus and Giroux, 2001).

Splashdown. Michael Milstein is an environment and science reporter at *The Oregonian* in Portland. Though he watched the Apollo 11 moon landing, he was three, so he barely remembers it.

Restoration: Pony Power. The author of 33 aviation books, Jay Miller is a retired aviation museum director.

Falling with the Falcon. Tom Harpole, who first wrote for *Air & Space/Smithsonian* about skydiving, has since forsworn freefalling.

Vintage Charmers. Chad Slattery is based in Los Angeles and specializes in aviation subjects. He is a co-founder of the International Society of Aviation Photographers.

Doug Fronius flew the glider from which Slattery photographed the Baby Albatross.

The World's Vintage Sailplanes 1908–45, Martin Simons (Kookabura Technical Publications, 1986).

In the Dark. Ed Regis is the author of six science books, including *The Biology of Doom: The History of America's Secret Germ Warfare Project* (Henry Holt, 1999).

The Calculators of Calm. William Triplett wrote about European astronauts for the Aug./Sept. 2003 issue.

The Annotated Airport. Senior editor Patricia Trenner flies at little airports with minimal signage to avoid getting lost while taxiing for takeoff.

Old Slow and Ugly. James L. Noles, Jr. writes in Birmingham, Alabama, where he also practices law. He is the author of *Twenty-Three Minutes to Eternity: The Final Voyage of the Escort Carrier USS* Liscome Bay (University of Alabama Press, 2004).

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www.airspacemag.com

The OS2U-3 Kingfisher may have been considered slow and ugly, but it was certainly photogenic. Visit the Web site to see more photographs of the much-beloved aircraft in its various capacities: scouting, bombing, anti-submarine patrols, search-and-rescue, and training. And you can read the full story behind Kingfisher pilot Tom Dougherty's capture and rescue off the North African coast, and the day he met General Patton…and didn't know it.

Two Kingfishers poised for launch from a battleship.

COURTESY JOSEPH McGUINNESS

FORECAST

In the Wings…

ANNUAL AIRSHOW SPECTACULAR

Invasion of the Aerobatic Air Racers
For this year's season, a slalom-style aerobatic race combines grace and speed.

So You Want To Be an Airshow Pilot
An inside look at the aspiring performer's long, hard road to the top.

Airshows 2005
When and where the shows are.

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Aerobatic star Mike Mangold whips his Zivko Edge 540 by racing pylons.

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IAO

RICHARD VANDER MEULEN

Riff Raff, *a Hawker Sea Fury belonging to Mike Keenum, is put through the paces by pilot Robert "Hoot" Gibson.*

Hawker in a Hurry

Back in 1995, Chicago resident Mike Keenum bought a Hawker Sea Fury—to be more precise, he bought a bunch of dusty parts that once made up a Sea Fury.

"I was just looking for a plane I could race," says Keenum. "And I happened to have a friend who had the pieces to a Sea Fury." A decade later, Keenum, 55, has fully reassembled the airplane, named it *Riff Raff*, and transformed it into one of the fastest World War II-era airplanes around.

Although he owns several airplanes and flies in airshows, aviation is just a hobby for Keenum, president of Orthosport, Inc., which provides physical therapy. Keenum leaves the air racing to friend Robert "Hoot" Gibson, a record-setting pilot and former astronaut.

Gibson was at the controls when *Riff Raff* won the Silver in the Unlimited division at the Reno Air Races last September, but Keenum flew it himself in October, setting a world record with the National Aeronautic Association.

Keenum's record and *Riff Raff*'s performance at Reno confirm the Sea Fury's reputation as one of the fastest piston engine aircraft ever. Produced by the British company Hawker Aircraft at the end of World War II, it was designed to be a Royal Navy carrier-based fighter with folding wings. The original Sea Fury used a Bristol Centaurus, 2,480-horsepower engine. *Riff Raff* has a Wright 3350 that produces more than 3,000 horsepower.

After a few engine problems over the years and a lot of fine-tuning, *Riff Raff* is now one of the fastest of the Sea Furies still flying. In 2003, it recorded its best speed at Reno (428.4 mph); last year, with a minimum speed of 414.2 mph, it won first place in the Unlimited Silver division, which is open to almost any piston engine aircraft.

But Keenum got the chance to make history when he flew *Riff Raff* himself on October 4, and set a record for piston engine speed over a closed circuit of 100 kilometers (62 miles) without payload.

"Even though what we were trying to do was different from racing, we basically set it up like we would have at Reno," Keenum says. "We had some questions on how *Riff Raff* would perform, especially since it was going to be kind of cold."

Although Keenum has logged 10,000 hours of flight time, only about 250 of those were in *Riff Raff*. Nonetheless, he says he was comfortable with attempting a record in the airplane. "It was a different experience because you're not used to flying around with the throttle all the way forward," Keenum says. "And at 10,500 feet you're so high you don't have any sensation of speed. I had to fly on instruments instead of looking out of the cockpit."

NAA staffer Mike Pablo was on hand in Kankakee, Illinois, to observe the record attempt. When he completed the course, Keenum had flown at an average speed of 370.6 mph. That's slower than *Riff Raff*'s speed at Reno, but Keenum said he was happy with how the Sea Fury performed in a different situation.

"It was very cool to set a record," Keenum says. "It's kind of nice to raise the bar, and I am sure someone will try to raise it even higher some day."

—Dustin Gouker

LOGBOOK

NAA Relaunches Web Site

NAA is launching a new Web site this year to kick off its centennial celebration. The site—*www.naa-usa.org* (or *www.naa.aero*)—will include features and content not previously available. Some of the new items on the Web site are:

Records Database

Currently, *World and United States Aviation & Space Records*, the NAA's annually published record book, is the only source in the United States for aviation records. Starting this year, NAA members will be able to search a complete online database to get information on any current record. Not all records will be available immediately in 2005, but the NAA expects to have much of the records database available online by the end of next year.

NAA History

The association has devoted an entire section to NAA history, including the origins of the NAA, a gallery of historic photographs, and a list of all the pilot license holders NAA certified in its earliest days, before the FAA took over that duty for the United States.

And More...

More news items will appear on the Web site regarding what's going on at the NAA and in aviation in general. Members will also be able to check out the NAA calendar, register for events online, and keep track of deadlines for awards nominations.

The Web site will offer members the opportunity to contribute feedback and ideas.

Moments & Milestones is produced in association with the National Aeronautic Association. Visit the NAA Web site at www.naa-usa.org *or call (703) 527-0226.*